

include all necessary dimensions and details on pipe joints, fittings, fitting specials, valves, appurtenances, design calculations, and material lists. The submittals shall include detailed layout, spool, or fabrication drawings which show all pipe spools, spacers, adapters, connectors, fittings, and pipe supports and seismic restraints necessary to accommodate the equipment and valves provided in a complete and functional system.

- B. All expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR at no increased cost to the OWNER.
- C. Submit as part of the shop drawings a statement from the pipe fabricator certifying that all pipes will be fabricated subject to a recognized Quality Control Program. An outline of the program shall be submitted to the CONSTRUCTION MANAGER for review prior to the fabrication of any pipe.

#### 1.4 QUALITY ASSURANCE

- A. Tests: Except where otherwise indicated, all materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. Welds shall be tested as indicated. Perform all tests at no additional cost to the OWNER.
- B. Welding Requirements: All welding procedures used to fabricate pipe shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.
- C. Welder Qualifications: All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing Work on the pipeline. Machines and electrodes similar to those used in the Work shall be used in qualification tests. Furnish all material and bear the expense of qualifying welders at no increased cost to the OWNER.

#### 1.5 MANUFACTURER'S SERVICE REPRESENTATIVE

- A. Where the assistance of a manufacturer's service representative is advisable, in order to obtain perfect pipe joints, supports, or special connections, furnish such assistance at no additional cost to the OWNER.

#### 1.6 MATERIAL DELIVERY, STORAGE, AND PROTECTION

- A. All piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground, to provide protection against oxidation caused by ground contact. All defective or damaged materials shall be replaced with new materials.

## 1.7 CLEANUP

- A. After completion of the Work, all remaining pipe cuttings, joining and wrapping materials, and other scattered debris, shall be removed from the site. The entire piping system shall be handed over in a clean and functional condition.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. All pipes, fittings, and appurtenances shall be furnished in accordance with the requirements of the applicable Sections of Divisions 2 and 15 and this Section.
- B. Pipe Supports: All pipes shall be adequately supported in accordance with the requirements of Section 15006 - Pipe Supports, and as indicated.
- C. Lining: All requirements pertaining to thickness, application, and curing of pipe lining, are in accordance with the requirements of the applicable Sections of Division 2, unless otherwise indicated.
- D. Coating: All requirements pertaining to thickness, application, and curing of pipe coating, are in accordance with the requirements of the applicable Sections of Division 2, unless otherwise indicated. Pipes above ground or in structures shall be field-painted in accordance with Section 09800 - Protective Coating.
- E. Pressure Rating: All piping systems shall be designed for the maximum expected pressure as defined in Section 02643 - Water Pipeline Testing and Disinfection, or as indicated on the piping schedule.
- F. Grooved Piping Systems: Piping systems with grooved joints and fittings may be provided, if approved by the CONSTRUCTION MANAGER, in lieu of screwed, flanged, welded, or mechanical joint systems for steel and ductile iron yard piping above and below ground within the property limits of pump stations, and similar installations. All grooved couplings on buried piping must be bonded. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer. The CONTRACTOR shall make the coupling manufacturer responsible for the selection of the correct style of coupling and gasket for each individual location.

### 2.2 PIPE FLANGES

- A. Flanges: Where the design pressure is 150 psi or less, flanges shall conform to either ANSI/AWWA C207 Class D or ANSI/ASME B16.5 150-pound class. Where the design pressure is greater than 150 psi, up to a maximum of 275 psi, flanges shall conform to either ANSI/AWWA C207 Class E, Class F, or ANSI/ASME B16.5 150-pound class. However, AWWA flanges shall not be exposed to test pressures greater than 125 percent of rated capacity. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected. Where the design pressure is greater than 275 psi up to a maximum of 700 psi, flanges shall conform to ANSI/ASME B16.5 300-pound class. Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise shown. Attachment of the

flanges to the pipe shall conform to the applicable requirements of ANSI/AWWA C207. Flanges for miscellaneous small pipes shall be in accordance with the standards specified for these pipes.

- B. Blind Flanges: Blind flanges shall be in accordance with ANSI/AWWA C207, or with the standards for miscellaneous small pipes. All blind flanges for pipe sizes 12 inches and over shall be provided with lifting eyes in form of welded or screwed eye bolts.
- C. Flange Coating: All machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.
- D. Flange Bolts: All bolts and nuts shall conform to Section 05500 - Miscellaneous Metalwork. Studs and bolts shall extend through the nuts a minimum of 1/4 inch. All-thread studs shall be used on all valve flange connections, where space restrictions preclude the use of regular bolts.
- E. Insulating Flanges: Insulated flanges shall have bolt holes 1/4 inch diameter greater than the bolt diameter.
- F. Insulating Flange Sets: Insulating flange sets shall be provided where shown. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inches or smaller and shall be made of acetal resin. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be two-piece and shall be made of polyethylene or phenolic. Steel washers shall be in accordance with ASTM A 325. Insulating gaskets shall be full-face.
- G. Insulating Flange Manufacturers, or Equal
  - 1. JM Red Devil, Type E
  - 2. Maloney Pipeline Products Co., Houston
  - 3. PSI Products, Inc., Burbank, California.
- H. Flange Gaskets: Gaskets for flanged joints shall be full-faced, 1/8-inch thick compressed sheets of asbestos-free aramid fiber base, with nitrile binder and nonstick coating, suitable for temperatures to 700 degrees F, a pH of 1 to 11, and pressures to 1,000 psig. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted.
- I. Flange Gasket Manufacturers, or Equal
  - 1. John Crane, Style 2160.
  - 2. Garlock, Style 3000.
  - 3. Durabla, Duran 8500

## 2.3 THREADED INSULATING CONNECTIONS

- A. General: Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.
- B. Materials: Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other nonconductive materials, and shall have ratings and properties to suit the service and loading conditions.

## 2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

- A. General: Cast mechanical-type couplings shall be provided where shown. The couplings shall conform to the requirements of ANSI/AWWA C606. Bolts and nuts shall conform to the requirements of Section 05500 - Miscellaneous Metalwork. All gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of all grooved piping shall conform with the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid stress on equipment, all equipment connections shall have rigid-grooved couplings, or harness sets in sizes where rigid couplings are not available, unless thrust restraint is provided by other means. The CONTRACTOR shall have the coupling Manufacturer's service representative verify the correct choice and application of all couplings and gaskets, and the workmanship, to assure a correct installation.
- B. Couplings for Steel Pipe, Manufacturers, or Equal
  - 1. Gustin-Bacon (banded or grooved).
  - 2. Victaulic Style 41 or 44 (banded, flexible).
  - 3. Victaulic Style 77 (grooved, flexible).
  - 4. Victaulic Style 07 or HP-70 (grooved, rigid).
- C. Ductile Iron Pipe Couplings, Manufacturers, or Equal
  - 1. Gustin-Bacon.
  - 2. Victaulic Style 31 (flexible or rigid grooving).

Note: Ductile iron pipe couplings shall be furnished with flush seal gaskets.

- D. Couplings for PVC Pipe, Manufacturers, or Equal
  - 1. Gustin-Bacon.
  - 2. Victaulic Style 775.

Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends.

## 2.5 SLEEVE-TYPE COUPLINGS

- A. Construction: Sleeve-type couplings shall be provided where indicated, in accordance with ANSI/AWWA C219 unless otherwise indicated, and shall be of steel with steel bolts, without pipe stop, and shall be of sizes to fit the pipe and fittings. The middle ring shall be not less than 1/4 inch in thickness and shall be either 5 or 7 inches long for sizes up to and including 30 inches and 10 inches long for sizes greater than 30 inches, for standard steel couplings, and 16 inches long for long-sleeve couplings. The followers shall be single-piece contoured mill section welded and cold-expanded as required for the middle rings. They shall be of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Bolts and nuts shall conform to the requirements of Section 05500 - Miscellaneous Metalwork. Buried sleeve-type couplings shall be epoxy-coated at the factory.
- B. Pipe Preparation: The ends of the pipe, where indicated, shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with outside diameter not more than 1/64 inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.
- C. Gaskets: Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Durometer hardness  $70 \pm 5$ , or equivalent suitable elastomer.
  1. The rubber in the gasket shall meet the following specifications:
    - a. Color - Jet Black.
    - b. Surface - Nonblooming.
    - c. Durometer Hardness -  $70 \pm 5$ .
    - d. Tensile Strength - 1,000 psi Minimum.
    - e. Elongation - 175 percent Minimum.
  2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. All gaskets shall meet the requirements of ASTM D 2000, AA709Z, meeting Suffix B13 Grade 3, except as noted above. All gaskets shall be compatible with the piping service and fluid utilized.
- D. Insulating Couplings: Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a rubber sleeve of an

insulating compound in order to obtain insulation of all coupling metal parts from the pipe.

- E. Restrained Joints: All sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be in accordance with the requirements of the appropriate reference standard, or as shown.

F. Manufacturers, or Equal

1. Dresser, Style 38.
2. Ford Meter Box Co., Inc., Style FC1 or FC3.
3. Smith-Blair, Style 411.

2.6 EXPANSION JOINTS

- A. All piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement, without exertion of undue forces to equipment or structures. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be of stainless steel, monel, rubber, or other materials, best suited for each individual service. Submit detailed calculations and manufacturer's shop drawings, guaranteeing satisfactory performance of all proposed expansion joints, piping layouts showing all anchors and guides, and information on materials, temperature and pressure ratings.

2.7 DISMANTLING JOINT

- A. Dismantling joints shall be provided where indicated. The dismantling joint shall be a self-contained flanged restrained joint fitting, including both flanged components and sufficient harness bars to withstand the imposed thrust. The dismantling joint shall allow for a minimum of 2-inches of longitudinal adjustment. Joint flanges shall be in accordance with AWWA C 207. The dismantling joint shall be designed so that the restraint system does not extend outside the flange diameter. The internal bore diameter shall match the inside diameter of the pipe.
- B. The dismantling joint shall comply with AWWA C 219 where applicable. The design pressure rating of the joint shall be equal to or greater than the mating flanges.
- C. Manufacturers, or equal
  1. Viking Johnson.

2.8 VENT SILENCER

- A. General: Vent silencers shall be provided as shown on the drawings. The material shall be compatible with the piping being installed. An insulating flange shall be used if metals are differing. A non-packed, reactive silencer shall be provided. The selection of



hole size, spacing, and pattern shall be performed by the manufacturer to optimize the overall quieting effect. A minimum of 15 dB reduction shall be achieved.

B. Manufacturers, or Equal

1. Fluid Kinetics Hush Pup
2. Burgess-Manning

2.9 PIPE THREADS

- A. All pipe threads shall be in accordance with ANSI/ASME B1.20.1.

**PART 3 -- EXECUTION**

3.1 GENERAL

- A. All pipes, fittings, and appurtenances shall be installed in accordance with the requirements of the applicable Sections of Divisions 2 and 15. The lining manufacturer shall take full responsibility for the complete, final product and its application. All pipe ends and joints at screwed flanges shall be epoxy-coated, to assure continuous protection.
- B. Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and rebars.
- C. Flanges shall be installed at least 6-inches from a wall. Fittings shall be installed with sufficient clearance for maintenance and removal and reinstallation.

- END OF SECTION -

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## SECTION 15006 - PIPE SUPPORTS

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide pipe supports, seismic restraints, hangers, guides, and anchors, complete, in accordance with the Contract Documents.

#### 1.2 CONTRACTOR SUBMITTALS

- A. General: Submittals shall be in accordance with Section 01300 - Contractor Submittals.
- B. Shop Drawings: Shop drawings shall include the following information:
  - 1. Drawings of pipe supports, restraints, hangers, anchors, and guides
  - 2. Calculations for special supports and anchors.

### PART 2 -- PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. Code Compliance: Piping systems and pipe connections to equipment shall be properly anchored and supported to prevent undue deflection, vibration, dislocation due to seismic events and line pressures, and stresses on piping, equipment, and structures. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping, except as supplemented or modified below. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.
- B. Structural Members: Wherever possible, pipes shall be supported from structural members. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided at no additional cost to the OWNER. All supplementary members shall be in accordance with the requirements of the building code and the American Institute of Steel Construction and shall be acceptable to the CONSTRUCTION MANAGER.
- C. Pipe Hangers: Pipe hangers shall be capable of supporting the pipe in all conditions of operation, allowing free expansion and contraction of the piping, and preventing excessive stress on equipment. Hangers shall have a means of vertical adjustment after erection. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves, shall include hydraulic shock suppressors. Hanger rods shall be subject to tensile loading only.
- D. Hangers Subject to Horizontal Movements: At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement. Where horizontal pipe movement is greater than 1/2-inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold to the hot position of

the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

- E. **Spring-Type Hangers:** Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate at all times the compression of the spring. Supports shall be capable of accommodating at least four times the maximum travel due to thermal expansion.
- F. **Thermal Expansion:** Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely in directions away from the anchored points. Components shall be structurally suitable to withstand loads imposed.
- G. **Heat Transmission:** Supports, hangers, anchors, and guides shall be so designed and insulated, that excessive heat will not be transmitted to the structure or to other equipment.
- H. **Riser Supports:** Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.
- I. **Freestanding Piping:** Free-standing pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure. Exterior, free-standing overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, with horizontal, welded steel angles and U-bolts or clamps securing the pipes.
- J. **Materials of Construction:**
  - 1. **General:** Pipe support assemblies, including framing, hardware, and anchors, shall be steel construction, galvanized after fabrication, unless otherwise indicated.
  - 2. **Submerged Supports:** Submerged piping, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel, unless otherwise indicated.
  - 3. **Corrosive:** Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel or FRP, unless otherwise indicated.
- K. **Point Loads:** Any meters, valves, heavy equipment, and other point loads on PVC, FRP, and other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, all supports on PVC, FRP, and other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

- L. Noise Reduction: To reduce transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar, suitable material at each pipe support, bracket, clip, or hanger.
- M. PVC piping and insulated piping shall have a stainless or galvanized steel shield wrapped around it at each support to prevent wearing at the supports.

## 2.2 SUPPORT SPACING

- A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads. Pipe support spacing shall not exceed the maximum spans in the tables below. For temperatures other than ambient temperatures, or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of all loading effects.

### 1. Support Spacing for Schedule 40 and Schedule 80 Steel Pipe

| Nominal Pipe Diameter<br>(inches) | Maximum Span<br>(feet) |
|-----------------------------------|------------------------|
| 1/2                               | 6                      |
| 3/4 and 1                         | 8                      |
| 1-1/4 to 2                        | 10                     |
| 3                                 | 12                     |
| 4                                 | 14                     |
| 6                                 | 17                     |
| 8 and 10                          | 19                     |
| 12 and 14                         | 23                     |
| 16 and 18                         | 25                     |
| 20 and Greater                    | 30                     |

- 2. Support Spacing for Welded Fabricated Steel Pipe should be as shown on the drawings.
- 3. Support Spacing for Ductile-Iron Pipe:

| Nominal Pipe Diameter<br>(inches) | Maximum Span<br>(feet)                                                                 |
|-----------------------------------|----------------------------------------------------------------------------------------|
| All Diameters                     | Two supports per pipe length<br>or 10 feet (one of the 2<br>supports located at joint) |

## 4. Support Spacing for Copper Tubing:

| Nominal Pipe Diameter<br>(inches) | Maximum Span<br>(feet) |
|-----------------------------------|------------------------|
| 1/2 to 1-1/2                      | 6                      |
| 2 to 4                            | 10                     |
| 6 and Greater                     | 12                     |

## 5. Support Spacing for Schedule 80 PVC Pipe:

| Nominal Pipe Diameter<br>(inches) | Maximum Span<br>(at 100 degrees F)<br>(feet) |
|-----------------------------------|----------------------------------------------|
| 1/2                               | 4                                            |
| 3/4                               | 4.5                                          |
| 1                                 | 5                                            |
| 1-1/4                             | 5.5                                          |
| 1-1/2                             | 5.75                                         |
| 2                                 | 6.25                                         |
| 3                                 | 7.5                                          |
| 4                                 | 8.25                                         |
| 6                                 | 10                                           |
| 8                                 | 11                                           |
| 10                                | 12.25                                        |
| 12                                | 13.25                                        |

## 2.3 MANUFACTURED SUPPORTS

A. Stock Parts: Where not specifically indicated, designs which are generally accepted as exemplifying good engineering practice and use stock or production parts, shall be utilized wherever possible. Such parts shall be locally available, new, of best commercial quality, designed and rated for the intended purpose.

## B. Steel Channel Framing System:

1. Steel channel frames shall be 1-5/8 inches wide by 1-5/8 or 3-1/4 inches high by 12-gauge metal thickness, unless otherwise shown in the drawings. Material shall conform to ASTM A 36, A 446, A 527, or A 570 (Grade 33 minimum). One side of the channel shall have a continuous open slot with intumed clamping ridges. Maximum allowable stress under any combination of applied uniformly distributed loads and concentrated loads shall not exceed those recommended in the AISC or AISI. Deflection shall not exceed 1/240 of span. Use multiple back-to-back channels to achieve these criteria if single channels are not sufficient. Products: Unistrut P1000 or P5000 Series, B-Line B11 of B22 Series, or equal.
2. Steel channels shall be hot-dipped galvanized per ASTM A 153.

3. Nuts shall be machined and case hardened. Provide rectangular nuts with the ends shaped to permit a quarter turn crosswise in the framing channel. Provide two serrated grooves in the nut to engage the inturned edges of the channel.
4. Pipe clamps (including attachment screws and nuts) shall be Unistrut P1100 or P2000 Series, B-Line B2000 series, or equal. Material shall be Type 304 stainless steel.
5. Hanger rods for trapezes shall be carbon steel (ASTM A 36, A 575, or A 576).
  - a. Flat Plate Fillings: Unistrut P1065, P1925; Superstrut AB-206, AB-207, or equal.
  - b. Post Bases: Unistrut P2072A, Superstrut AP-232, or equal.
  - c. 90-Degree Brackets: Unistrut P1326, P1346,; Superstrut AB-203; or equal.
  - d. Rounded-End Flat Plate Fittings: Unistrut P2325, Superstrut X-240, or equal.

C. Manufacturer's, or Equal:

1. Basic Engineers Inc., Pittsburgh, PA;
2. Bergen-Paterson, Pipesupport Corp., Woburn, MA;
3. Grinnell Corp. (Supply Sales Company), Cranston, RI;
4. NPS Products, Inc., Westborough, MA;
5. Power Piping Company, Pittsburgh, PA;
6. Aickinstrut, Inc., Seattle, WA;
7. Entrum Industries Inc. (Strut Tech), Redmond, WA.

2.4 COATING

- A. Galvanizing: Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. Other Coatings: Other than stainless steel or non-ferrous supports, all supports shall receive protective coatings in accordance with the requirements of Section 09800 - Protective Coating.

**PART 3 -- EXECUTION**

3.1 INSTALLATION

- A. General: Pipe supports, seismic restraints, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed

instructions and ASME B31.1 - Power Piping. Concrete inserts for pipe hangers and supports shall be coordinated with the form work.

- B. Appearance: Pipe supports and hangers shall be positioned to produce an orderly, neat piping system. Hanger rods shall be vertical, without offsets. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, without interference with other work.

### 3.2 FABRICATION

- A. Quality Control: Pipe hangers, supports, and seismic restraints shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available. Fabricated supports shall be neat in appearance without sharp corners, burrs, and edges.

- END OF SECTION -

**SECTION 15010 - MILL PIPING - EXPOSED AND BURIED****PART 1 -- GENERAL****1.1 THE REQUIREMENT**

- A. The CONTRACTOR shall furnish and install all exposed and buried mill piping as shown and indicated, complete, including small steel pipe, stainless steel pipe, copper tubing, solvent-welded PVC pipe, cast iron soil pipe fittings, gaskets, bolts, insulating connections, pipe insulation, and such other specialties as required for a complete and operable piping system in accordance with the Contract Documents.

**1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS****A. Commercial Standards**

|                  |                                                                                      |
|------------------|--------------------------------------------------------------------------------------|
| ANSI/ASME B16.3  | Malleable Iron Threaded Fittings                                                     |
| ANSI/ASME B16.4  | Gray Iron Threaded Fittings,                                                         |
| ANSI/ASME B16.5  | Pipe Flanges and Flanged Fittings, NPS ½ to NPS 24                                   |
| ANSI/ASME B16.11 | Forged Steel Fittings, Socket-Welding and Threaded                                   |
| ANSI/ASME B16.12 | Cast-Iron Threaded Drainage Fittings                                                 |
| ANSI/ASME B16.15 | Cast Bronze Threaded Fittings, Classes 125 and 250                                   |
| ANSI/ASME B16.21 | Nonmetallic Flat Gaskets for Pipe Flanges                                            |
| ANSI/ASME B16.22 | Wrought Copper and Copper Alloy Solder Joint Pressure Fittings                       |
| ANSI/AWWA C 215  | Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines               |
| ASTM A 53        | Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless |
| ASTM A 74        | Specification for Cast Iron Soil Pipe and Fittings                                   |
| ASTM A 105       | Specification for Carbon Steel, Forgings for Piping Applications                     |
| ASTM A 106       | Specification for Seamless Carbon Steel Pipe for High Temperature Service            |
| ASTM A 312       | Specification for Seamless and Welded Austenitic Stainless Steel Pipe                |



ASTM B 88

Specifications for Seamless Copper Water Tube

ASTM D 1785

Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

### 1.3 CONTRACTOR SUBMITTALS

- A. For the materials and equipment items supplied under the provisions of this Section, submit copies of the manufacturer's product specifications and performance details according to the requirements of Section 01300 - Contractor Submittals.

## PART 2 -- PRODUCTS

### 2.1 SMALL STEEL PIPE

- A. Unless otherwise indicated, galvanized steel pipe and black steel pipe in sizes 6 inches in diameter and smaller shall conform to the requirements of ASTM A 53 or ASTM A 106, as called out in the piping schedule and shall be Schedule 40 or 80 as indicated. Galvanized steel pipe shall not be cement mortar lined unless otherwise indicated. Fittings for galvanized steel pipe shall be of galvanized malleable iron, with NPT or grooved ends. Black pipe may have welded joints, with standard or extra strong welding fittings, or fittings indicated.

### 2.2 STAINLESS STEEL PIPE

- A. Unless otherwise indicated, stainless steel pipe shall be Type 316 Schedule 40 threaded pipe conforming to ASTM A 312 with stainless steel threaded fittings, or with stainless steel welding fittings, where indicated. Lightweight stainless steel pipe shall be Type 316 Schedule 10 pipe conforming to ASTM A 312, with stainless steel welding fittings, or fittings as indicated.

### 2.3 COPPER TUBING

- A. Copper tubing shall conform to the requirements of ASTM B 88 and shall be Type K, soft temper for buried tubing and hard-drawn for above-ground application. Fittings shall be soldered or sweated on and shall be of wrought copper conforming to ANSI B16.22. Soldered joints shall contain 95-percent tin and 5-percent antimony. No solders or fluxes containing more than 0.2 percent of lead shall be used.

### 2.4 PVC (POLYVINYL CHLORIDE) PRESSURE PIPE, SOLVENT-WELDED

- A. PVC pipe shall be made from all new rigid unplasticized polyvinyl chloride and shall be Normal Impact Class 12454-B, Schedule 80, conforming to ASTM D 1785, unless otherwise indicated. Fittings shall be of the same material as the pipe. Unless otherwise indicated, joint design shall be for solvent-welded construction to the pipe manufacturer's specifications. Threaded joints shall be made with Teflon tape, only.

## 2.5 CAST IRON SOIL PIPE

- A. Cast iron soil pipe and fittings shall be made of gray cast iron, service weight, conforming to ASTM A 74, suitable for service in drainage, waste, vent, and sewer lines. The pipes and fittings shall have caulked lead bell and spigot joints, or hubless joints with stainless steel couplings over suitable elastomer sleeves.

## 2.6 DRAIN TRAPS

- A. Drain traps shall be furnished and installed in accordance with the requirements of Section 15000 - Piping, General.

## 2.7 SLEEVE-TYPE COUPLINGS

- A. Sleeve-type couplings shall be furnished and installed in accordance with the requirements of Section 15000 - Piping, General.

## 2.8 GASKETS AND BOLTS

- A. Except as otherwise indicated, gaskets for flanged joints shall be in accordance with the requirements of Section 15000 - Piping, General.
- B. Except as otherwise indicated, bolts shall conform to the requirements of Section 05500 -Miscellaneous Metalwork.

## 2.9 INSULATING CONNECTIONS

- A. General: Insulating bushings, unions, couplings or flanges, as appropriate, shall be used for joining pipes of dissimilar metals, and for piping systems where corrosion control and cathodic protection are involved, in accordance with the requirements of Section 15000 -Piping, General.
- B. Material: Insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

## 2.10 PIPE SUPPORTS

- A. Pipe Supports, hangers, anchors, seismic restraints, and guides shall be in accordance with the requirements of Section 15006 - Pipe Supports.

# PART 3 -- EXECUTION

## 3.1 INSTALLATION

- A. Small Steel Pipe: Buried galvanized or black steel pipe shall be coated as specified in Section 09800 - Protective Coating or provided with an extruded high density polyethylene coating with minimum thickness of 35 mils, in accordance with Section 09820 - Steel Pipe Dielectric Coating System (Extruded Polyolefin).

- B. Plastic Pipe: PVC, pipe joints shall be solvent-welded in accordance with the manufacturer's instructions. Expansion joints or pipe bends shall be provided to absorb pipe expansion over a temperature range of 100 degrees F, unless otherwise indicated. Care shall be taken to provide sufficient supports, anchors, and guides, to avoid stress on the piping. Obtain the services of the pipe manufacturer, to instruct the pipe fitters in the correct way of making solvent welded and threaded joints. Only clean, fresh primer and solvent shall be used at all times at the recommended temperatures.
- C. Drain Traps: Drain traps shall be installed at low points in air and gas lines or elsewhere where indicated. Liquid outlets shall be piped to the nearest floor drain or open sump.
- D. Couplings: Pipe couplings shall be installed in strict accordance with the manufacturer's printed recommendations, using the correct style coupling and gasket for any given application.
- E. Gaskets for Flanged Joints: Gaskets shall be in accordance with the requirements of Section 15000 - Piping, General.
- F. Insulating Connections: All insulating connections shall be installed in accordance with manufacturer's printed instructions. Care shall be exercised to prevent damage to insulating fittings, while making up the joints.

### 3.2 INSTALLING THREADED PIPING

- A. Ream, clean, and remove burrs from threaded piping before making up joints. Apply thread lubricant to threaded ends before installing fittings, couplings, unions, or joints.

### 3.3 INSTALLING UNIONS

- A. Provide unions on exposed piping 3 inches and smaller as follows:
  - 1. At every change in direction (horizontal and vertical).
  - 2. Six to twelve inches downstream of valves.
  - 3. Every 40 feet in straight piping runs.
  - 4. Where shown in the drawings.

### 3.4 CONTINUITY BONDS

- A. Where required by the Contract Documents, all metallic pipe joints, except field-welded joints and insulating joints, shall be continuity bonded in accordance with the requirements of Section 15000 - Piping, General.

- END OF SECTION -

## SECTION 15180 - STRAINERS

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide pipe strainers where indicated, complete and operable, in accordance with the Contract Documents.
- B. All strainers shall be of ample size, with the perforations suitable for each individual service, and designed for easy cleaning and removal of the strainer basket.

#### 1.2 CONTRACTOR SUBMITTALS

- A. General: Submittals shall be in accordance with Section 01300 - Contractor Submittals.
- B. Shop Drawings: Shop drawings shall include construction details, sizes, dimensions, materials, and pressure ratings, in accordance with Section 11000 - Equipment General Provisions.

### PART 2 -- PRODUCTS

#### 2.1 STRAINERS (METAL BODY)

- A. Equipment Requirements: Strainers shall be of the Y-pattern or basket type, with flush connections, cast iron or bronze bodies, and screwed ends for sizes 3-inch and smaller, and flanged ends for sizes greater than 3 inches. They shall be designed for not less than 250-psi working pressure in sizes 3 inches and smaller, and 125-psi or 250-psi working pressure as required in sizes over 3 inches. Strainers shall be of the same size as the entering pipe and the screens shall have a free area of not less than three times the cross-sectional area of the pipe.
- B. Screens: Unless otherwise indicated or required by the service fluid, the screens shall be of Type 316 stainless steel or monel construction, easily removable, with the following mesh or perforations:

| <u>Strainer Size</u> | <u>Size of Perforations</u> |
|----------------------|-----------------------------|
| 1/4 - through 2-inch | 20 mesh                     |
| 2 1/2 through 5-inch | 1/16-inch dia. or 3/64-inch |
| 6 through 8-inch     | 1/8-inch dia.               |
| over 8-inch          | 3/16-inch dia.              |

#### C. Manufacturers, or Equal

- 1. Armstrong - Yoshitake, Inc.
- 2. Fisher Controls Company.
- 3. G. A. Industries, Inc.

4. Mueller Steam Specialty.
5. Watts Regulator Company.

## 2.2 STRAINERS (PLASTIC BODY)

- A. Equipment Requirements: Strainers shall be of the Y-pattern type with removable screen, cap, and EPDM or Viton O-ring seal, and PVC or CPVC body with solvent welded, screwed or flanged ends, rated for the following pressures at 70 degrees F:

150 psi for sizes 1/2 to 1 inch  
90 psi for sizes 1-1/2 to 2 inches  
60 psi for sizes 3 to 4 inches

- B. Screen: The screens shall be of PVC, CPVC or stainless steel as best suited for each application, with a free area of twice the cross-sectional area of the pipe and 1/32-inch perforations.

- C. Manufacturers, or Equal

1. ASAHI/AMERICA.
2. Hayward Industrial Products, Inc.

## PART 3 -- EXECUTION

### 3.1 INSTALLATION

- A. Unless otherwise indicated, strainers shall be provided ahead of any control valves, regulators, steam and condensate traps, and where indicated, and shall be preceded by shut-off valves.
- B. All strainers shall be installed in accordance with the Manufacturer's written instruction, in easily accessible locations for cleaning.

- END OF SECTION -

## SECTION 15183 - GAUGES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide pressure and vacuum gauges, complete and operable, including fittings, snubbers, connections, gaskets, supports, and accessories, in accordance with the Contract Documents.

### PART 2 -- PRODUCTS

#### 2.1 PRESSURE AND VACUUM GAUGES

- A. General: Pressure gauges shall be provided on suction and discharge connections to pumps as indicated under pumps; on discharge connections from compressors; on each side of pressure reducing valves; and where shown. In all locations (such as certain pump suction connections) where pressures may vary from below to above atmospheric pressure, compound gauges shall be installed.
- B. Gauge Construction: Gauges shall be industrial quality type with Type 316 stainless steel movement and stainless steel or alloy case. Unless otherwise indicated, gauges shall have a 3-1/2-inch dial, 1/4-inch threaded connection, a Type 316 stainless steel snubber adapter, and a shut-off valve. Gauges shall be calibrated to read in applicable units, with an accuracy of 1 percent, to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected. All gauges shall be vibration and shock resistant.
- C. Gauge Manufacturers, or Equal
  - 1. Marsh Instrument Company
  - 2. Ashcroft Industrial Instruments (Dresser)
  - 3. Foxboro/Jordan, Inc.
  - 4. Marshalltown Instruments, Inc.
  - 5. U.S. Gauge Div. of Ametek.
- D. Snubber Manufacturers, or Equal
  - 1. Cajon Company
  - 2. Weksler Instruments Corp.

### **PART 3 -- EXECUTION**

#### **3.1 INSTALLATION**

- A. All gauges shall be installed with the face in the vertical position, at the locations indicated, and in strict accordance with the manufacturer's printed instructions. Install snubbers where needed to dampen gauge pulsations. Care shall be taken to minimize the effect of water hammer or vibrations on the gauges. In extreme cases, the gauges may have to be mounted independently, with flexible connectors.
- B. Gauges shall have block and bleed valves used as isolation valves. The valves shall be Hex Valves, Sabre Valves, or an approved equal.

- END OF SECTION -



## SECTION 15200 - VALVES, GENERAL

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide all valves, actuators, and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to all valves and valve actuators except where otherwise indicated. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls indicated in other Sections of the Specifications.
- C. Unit Responsibility: A single manufacturer shall be made responsible for coordination of design, assembly, testing, and furnishing of each valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve section. Unless indicated otherwise, the responsible manufacturer shall be the Manufacturer of the valve.
- D. Single Manufacturer: Where two or more valves of the same type or size are required, the valves shall be furnished by the same Manufacturer.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

|            |                                                                                                         |
|------------|---------------------------------------------------------------------------------------------------------|
| ASTM A 48  | Specification for Gray Iron Castings,                                                                   |
| ASTM A 126 | Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings                             |
| ASTM A 216 | Specification for Steel Castings, Carbon Suitable for Fusion Welding for High Temperature Service       |
| ASTM A 351 | Specification for castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts     |
| ASTM A 395 | Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures    |
| ASTM A 515 | Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service |
| ASTM A 536 | Specification for Ductile Iron Castings                                                                 |
| ASTM B 62  | Specification for Composition Bronze or Ounce Metal Castings                                            |

ASTM B 584

Specification for Copper Alloy Sand Castings  
for General Applications

MSS SP25

Standard Marking Systems for Valves,  
Fittings, Flanges, and Unions

### 1.3 CONTRACTOR SUBMITTALS

- A. General: Submittals shall be furnished in accordance with Section 01300 - Contractor Submittals.
- B. Shop Drawings: Shop drawings shall contain the following information:
  - 1. Valve name, size, Cv factor for 10% through 100% in increments of 10%, pressure rating, identification number (if any), and specification section number.
  - 2. Complete information on valve actuator, including size, Manufacturer, model number, limit switches, and mounting. Dimensions and orientation of valve actuator needs to be included.
  - 3. Cavitation limits for all control valves.
  - 4. Assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, handwheels, position indicators, limit switches, integral control systems, needle valves, and control systems.
  - 5. Data in accordance with Section 16460 - Electric Motors for all electric motor-actuated valves.
  - 6. Complete wiring diagrams and control system schematics.
  - 7. Valve Labeling: A schedule of valves to be labeled, indicating in each case the valve location and the proposed wording for the label.
  - 8. Show valve linings and coatings. Submit manufacturer's catalog data and descriptive literature. Indicate materials of construction, specification (AISI, ASTM, SAE, CDA, etc.) and grade or type.
- C. Operation and Maintenance Manual: The Manual shall contain the required information for each valve. Manual must conform to specification 01300, para 1.13.
- D. Spare Parts List: A Spare Parts List shall contain the required information for each valve assembly, where indicated. The spare parts listed herein are to be included in the CONTRACTOR's lump sum portion of the contract.
- E. Factory Test Data: Where indicated, signed, dated, and certified factory test data for each valve requiring certification shall be submitted before shipment of the valve. The data shall also include certification of quality and test results for factory-applied coatings. Submit six copies of a report verifying that the valve interior linings and exterior coatings

have been tested for holidays and lining thickness. Describe test results and repair procedures for each valve.

#### 1.4 WARRANTY

- A. All valves 24-inch and larger in diameter shall be warranted by the manufacturer against material and workmanship defects for a period not less than 2 years, or longer if otherwise stated, which commences at final acceptance of the project. The manufacturer's warranty shall be submitted prior to final acceptance.

### PART 2 -- PRODUCTS

#### 2.1 PRODUCTS

- A. General: All valves and gates shall be new and of current manufacture. All shut-off valves 6-inches and larger shall have actuators with position indicators. Buried valves shall be provided with valve boxes and covers containing position indicators and valve extensions. Manual shut-off valves mounted with centerline of handwheel higher than 7-feet above working level shall be provided with chain actuators.
- B. Valve Actuators: Unless otherwise indicated, valve actuators shall be in accordance with Section 15201 - Valve and Gate Actuators.
- C. Protective Coating: The exterior surfaces of all valves and the wet interior surfaces of all ferrous valves of sizes 4 inches and larger shall be coated in accordance with Section 09800 - Protective Coating. The valve Manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with these Specifications. Flange faces of valves shall not be epoxy coated but shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is complete.
- D. Valve Labeling: Except when such requirement is waived in writing, a label shall be provided on all shut-off valves and control valves except for hose bibbs and chlorine cylinder valves. The label shall be of 1/16-inch plastic or stainless steel, minimum 2 inches by 4 inches in size, as indicated in Section 15005 - Piping Identification Systems, and shall be permanently attached to the valve or on the wall adjacent to the valve as directed by the CONSTRUCTION MANAGER.
- E. Valve Testing:
  - 1. All valves 3 inches and smaller shall undergo the Manufacturer's standard test.
  - 2. As a minimum, unless otherwise indicated, each valve body 4 inches and larger shall be tested hydrostatically to 1.5 times its rated 100 degrees F design water-working pressure, for a period of 5 minutes, without showing any leaks or loss of pressure. In addition, each valve 4 inches and larger shall undergo a functional test to demonstrate satisfactory operation throughout its operating cycle, and a closure test at rated 100 degrees F water-working pressure for a period of 5 minutes to demonstrate tight shut-off. Minor stem seal leakage shall not be a cause for rejection.

3. All valves 24 inches and larger shall be factory tested as complete assembled units including actuator and the tests shall be witnessed by the CONSTRUCTION MANAGER. The CONTRACTOR shall furnish notification to the CONSTRUCTION MANAGER a minimum of 4 weeks prior to testing. The CONTRACTOR shall submit all written factory testing results to the CONSTRUCTION MANAGER for review prior to shipment.
- F. Certification: Prior to shipment, submit for all valves over 4 inches in size, certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, and ASTM.
- G. Valve Marking: All valve bodies shall be permanently marked in accordance with MSS SP25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

## 2.2 MATERIALS

- A. General: All materials shall be suitable for the intended application. Materials not specified shall be high-grade standard commercial quality, free from all defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended. Unless otherwise specified, valve bodies shall conform to the following requirements:
  1. Cast Iron: Cast iron valve bodies shall be of close-grained gray cast iron, conforming to ASTM A 48 - Specification for Gray Iron Castings, Class 30, or to ASTM A 126 - Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B.
  2. Ductile Iron: Ductile iron valve bodies shall conform to ASTM A 536 - Specification for Ductile Iron Castings, or to ASTM A 395 - Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
  3. Steel: Steel valve bodies shall conform to ASTM A 216 - Specification for Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, Grade WCB or to ASTM A 515 - Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service, Grade 70.
  4. Bronze: Bronze valve bodies shall conform to ASTM B 62 - Specification for Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Specification for Copper Alloy Sand Castings for General Applications.
  5. Stainless Steel: Stainless steel valve bodies and trim shall conform to ASTM A 351 - Specification for Castings, Austenitic, for Austenitic-Ferritic (Duplex) for Pressure-Containing Parts, Grade CF8M, or shall be Type 316 stainless steel.

## 2.3 VALVE CONSTRUCTION

- A. Bodies: Valve bodies shall be cast, forged, or welded of the materials indicated, with smooth interior passages. Wall thicknesses shall be uniform in agreement with the applicable standards for each type of valve, without casting defects, pinholes, or other defects that could weaken the body. All welds on welded bodies shall be performed with

approved welding procedures and procedure qualifications. All welders shall be certified. Welds shall be ground smooth. Valve ends shall be as indicated, and be rated for the maximum temperature and pressure to which the valve will be subjected.

- B. Bonnets: Valve bonnets shall be clamped, screwed, or flanged to the body and shall be of the same material, temperature, and pressure rating as the body. The bonnets shall have provision for the stem seal with the necessary glands, packing nuts, or yokes.
- C. Stems: Valve stems shall be of the materials indicated, or, if not indicated, of the best commercial material for the specific service, with adjustable stem packing, O-rings, Chevron V-type packing, or other suitable seal. Where subject to dezincification, bronze valve stems shall conform to ASTM B 62, containing not more than 5 percent of zinc or more than 2 percent of aluminum, with a minimum tensile strength of 60,000 psi, a minimum yield strength of 40,000 psi, and an elongation of at least 10 percent in 2 inches. Where dezincification is not a problem, bronze conforming to ASTM B 584 may be used. Stems made of 316 stainless steel to ASTM A 182, Grade F6 of 17-4 PH to ASTM A 564, Grade 630 are also acceptable.
- D. Internal Parts: Internal parts and valve trim shall be as indicated for each individual valve. Where not indicated, valve trim shall be of Type 316 stainless steel or other best suited material.
- E. Nuts and Bolts: All nuts and bolts on valve flanges and supports shall be in accordance with Section 05500 - Miscellaneous Metalwork.

## 2.4 VALVE ACCESSORIES

- A. All valves shall be furnished complete with the accessories required to provide a functional system.

## 2.5 SPARE PARTS

- A. Where indicated, furnish the required spare parts suitably packaged and labeled with the valve name, location, and identification number. Also furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve. All spare parts are intended for use by the OWNER, only, after expiration of the guarantee period.
- B. The spare parts listed herein are to be included in the CONTRACTOR's lump sum portion of the contract.

## 2.6 MANUFACTURERS

- A. Manufacturer's Qualifications: All valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the valves indicated.

### **PART 3 -- EXECUTION**

#### **3.1 VALVE INSTALLATION**

- A. General: All valves, actuating units, stem extensions, valve boxes, and accessories shall be installed in accordance with the Manufacturer's written instructions and as indicated. All gates shall be adequately braced to prevent warpage and bending under the intended use. Valves shall be firmly supported to avoid undue stresses on the pipe.
- B. Access: All valves shall be installed with easy access for actuation, removal, and maintenance and to avoid interference between valve actuators and structural members, handrails, or other equipment.
- C. Valve Accessories: Where combinations of valves, sensors, switches, and controls are indicated, assemble and install such items so that all systems are compatible and operating properly. The relationship between interrelated items shall be clearly noted on shop drawing submittals.

- END OF SECTION -

## SECTION 15201 - VALVE ACTUATORS

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide valve actuators and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to all valves except where otherwise indicated in the Contract Documents.
- C. Unit Responsibility: A single manufacturer shall be made responsible for furnishing the Work and for coordination of design, assembly, testing, and installation of the Work of each type of valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve and gate section. Unless otherwise indicated, the single manufacturer shall be the Manufacturer of the valve.
- D. Single Manufacturer: Where two or more valve actuators of the same type or size are required, the actuators shall all be produced by the same manufacturer. The manufacturer will have a minimum of 5 years of experience in producing and installing specified actuators.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

|                |                                                                                                          |
|----------------|----------------------------------------------------------------------------------------------------------|
| ANSI/AWWA C540 | Standard for Power-Actuating Devices for Valves and Sluice Gates                                         |
| JIC H-1        | Joint Industrial Council, Hydraulic Standards for Industrial Equipment and General Purpose Machine Tools |
| ASTM A 105     | Specification for Forgings, Carbon Steel, for Piping Components                                          |
| ASTM A 276     | Specification for Stainless Steel Bars and Shapes                                                        |
| ASTM F 593     | Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs                                       |
| ASTM F 594     | Specification for Stainless Steel Nuts                                                                   |
| ASME B 31.1    | Power Piping                                                                                             |
| NFPA/NEC       | National Electrical Code (Latest Edition)                                                                |
| ANSI/NEMA      | National Electrical Manufacturers Association (As Applicable)                                            |



### 1.3 CONTRACTOR SUBMITTALS

- A. General: Submittals shall be furnished in accordance with Section 15200 - Valves, General. The following information should also be included in the submittal.
1. Maximum torque required to open and close each motor-operated valve.
  2. Submit motor data including nameplate data, insulation type, duty rating, and torque output at duty rating.
  3. Submit electrical schematic drawings and physical wiring diagrams showing all components.
  4. Submit certified factory performance test records.
- B. Shop Drawings: Shop Drawings of all actuators shall be submitted together with the valve submittals as a complete package.

### 1.4 WARRANTY

- A. Actuators for all valves, which require a warranty, shall also be warranted against material and workmanship defects for the same period as the valves. The manufacturer's warranty shall be submitted with the valves' warranties prior to acceptance.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. General: Unless otherwise indicated, all shutoff and throttling valves, and externally actuated valves, shall be provided with manual or power actuators. Furnish all actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, handwheels, levers, chains, and extensions, as applicable. All actuators shall be capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering. All wires of motor-driven actuators shall be identified by unique numbers.
- B. Manufacturers: Where indicated, certain valves may be provided with actuators manufactured by the valve Manufacturer. Where actuators are furnished by different manufacturers, coordinate selection to have the fewest number of manufacturers possible.
- C. Materials: All actuators shall be current models of the best commercial quality materials and liberally sized for the maximum expected torque. All materials shall be suitable for the environment in which the valve is to be installed.
- D. Mounting: All actuators shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and of ample strength. The word "open" shall be cast on each valve with an arrow indicating the direction to open in the counter-

clockwise direction. All gear and power actuators shall be equipped with position indicators.

- E. Standard: Unless otherwise indicated and where applicable, all actuators shall be in accordance with ANSI/AWWA C 540 - AWWA Standard for Power-Actuating Devices for Valves and Sluice Gates.
- F. Functionality: Electric, pneumatic, and hydraulic actuators shall be coordinated with power and instrumentation equipment indicated elsewhere in the Contract Documents. Electrically operated valves shall be UL listed.

## 2.2 MANUAL ACTUATORS

- A. General: Unless otherwise indicated, all valves shall be furnished with manual actuators. Valves in sizes up to and including 4 inches shall have direct acting lever or handwheel actuators of the Manufacturer's best standard design. Larger valves shall have gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the handwheel. All buried and submerged gear-assisted valves, all gear-assisted valves for pressures higher than 250 psi, all valves 30 inches in diameter and larger, and where so indicated, shall have worm-gear actuators, hermetically sealed and grease-packed, where buried or submerged. All other valves 6 inches to 24 inches in diameter may have traveling-nut actuators, worm-gear actuators, spur- or bevel-gear actuators, as appropriate for each valve.
- B. Buried Valves: Unless otherwise indicated, all buried valves shall have extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys. Where so indicated, buried valves shall be in cast-iron, concrete, or similar valve boxes with covers of ample size to allow operation of the valve actuators. Covers of valve boxes shall be permanently labeled as requested by the local Utility Company or the CONSTRUCTION MANAGER. Wrench-nuts shall comply with AWWA C 500 -Metal - Seated Gate Valves for Water Supply Service, and a minimum of 2 operating keys, or one key per 10 valves, whichever is greater, shall be furnished. Operating keys shall be included as part of the submittal.
- C. Chain Actuator: Manually activated valves with the stem located more than 7 feet above the floor or operating level shall be furnished with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains, and be provided by the valve Manufacturer. The wheel and guide shall be of ductile iron, cast iron, or steel, and the chain shall be hot-dip galvanized steel or stainless steel, extending to 5 feet 6 inches above the operating floor level. The valve stem of chain-actuated valves shall be extra strong to allow for the extra weight and chain pull. Hooks shall be provided for chain storage where chains interfere with pedestrian traffic.
- D. Floor Boxes: Hot-dip galvanized cast-iron or steel floor boxes and covers to fit the slab thickness shall be provided for all operating nuts in or below concrete slabs. For operating nuts in the concrete slab, the cover shall be bronze-bushed.
- E. Manual Worm-Gear Actuator: The actuator shall consist of a single or double reduction gear unit contained in a weatherproof cast-iron or steel body with cover and minimum

12-inch diameter handwheel. The actuator shall be capable of 90-degree rotation and shall be equipped with travel stops capable of limiting the valve opening and closing. The actuator shall consist of spur or helical gears and worm-gearing. The spur or helical gears shall be of hardened alloy steel and the worm-gear shall be alloy bronze. The worm-gear shaft and the handwheel shaft shall be of 17-4 PH or similar stainless steel. All gearing shall be accurately cut with hobbing machines. Ball or roller bearings shall be used throughout. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator. All gearing shall be designed for a 100 percent overload.

- F. **Traveling-Nut Actuator:** The actuator shall consist of a traveling-nut with screw (Scotch yoke) contained in a weatherproof cast-iron or steel housing with spur gear and minimum 12-inch diameter handwheel. The screw shall run in two end bearings, and the actuator shall be self-locking to maintain the valve position under any flow condition. The screw and gear shall be of hardened alloy steel or stainless steel, and the nut and bushings shall be of alloy bronze. The bearings and gear shall be grease-lubricated by means of grease nipples. All gearing shall be designed for a 100 percent overload.

## 2.3 ELECTRIC MOTOR ACTUATORS

### A. General

1. **Equipment Requirements:** Where electric motor actuators are indicated, an electric motor-actuated valve control unit shall be attached to the actuating mechanism housing by means of a flanged motor adaptor piece.
2. **Gearing:** The motor actuator shall include the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weatherproof NEMA 4 assembly. The actuator shall be a single or double reduction unit consisting of spur or helical gears and worm-gearing. The spur or helical gears shall be of hardened alloy steel and the worm-gear shall be alloy bronze. All gearing shall be accurately cut with hobbing machines. All power gearing shall be grease- or oil-lubricated in a sealed housing. Ball or roller bearings shall be used throughout. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the electric actuator.
3. **Starting Device:** Except for modulating valves, the unit shall be so designed that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve. The device should allow free movement at the stem nut before imparting the hammer blow. The actuator motor must attain full speed before stem load is encountered.
4. **Switches and Wiring:** Travel in the opening and closing directions shall be governed by a switch responsive to mechanical torque developed in seating the valve, or by an obstruction met in opening or closing the valve, or by an on-board microprocessor. The torque switch shall be adjustable and shall function without auxiliary relays or devices, or it shall be adjustable in 1 percent increments, sensed by a pulse-counter which receives 15 pulses per rotation of the unit. The geared limit switches shall be of the open type and shall be actuated by a rotor cam with

four contacts to each cam or gear train. The actuator shall have a number of gear trains as required to produce the operation indicated. The actuator shall be wired in accordance with the schematic diagram. All wiring for external connections shall be connected to marked terminals. One 1-inch and one 1-1/4-inch conduit connection shall be provided in the enclosing case. A calibration tag shall be mounted near each switch correlating the dial setting to the unit output torque. Position limit switches and associated gearing shall be an integral part of the valve actuator. To provide the best possible accuracy and repeatability, limit-switch gearing shall be of the "counting" intermittent type, made of stainless steel, grease-lubricated, and enclosed in its own gearcase to prevent dirt and foreign matter from entering the gear train. Switches shall not be subject to breakage or slippage due to over-travel. Traveling-nuts, cams, or microswitch tripping mechanisms shall not be used. Limit-switches shall be of the heavy-duty open contact type with rotary wiping action.

5. **Handwheel Operation:** A permanently attached handwheel shall be provided for emergency manual operation. The handwheel shall not rotate during electrical operation. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60 pounds per foot, and the maximum force required on the rim of the handwheel shall not exceed 60 pounds. An arrow and either the word "open" or "close" shall be cast or permanently affixed on the handwheel to indicate the appropriate direction to turn the handwheel.
6. **Motor:** The motor shall be of the totally enclosed, nonventilated, high-starting torque, low-starting current type for full voltage starting. It shall be suitable for operation on 480-volt, 3-phase, 240-volt, single-phase, or 120-volt, single-phase, 60-Hz current, and have Class F insulation and a motor frame with all dimensions in accordance with the latest revised NEMA MG Standards. The observed temperature rise by thermometer shall not exceed 55 degrees C above an ambient temperature of 40 degrees C when operating continuously for 15 minutes under full rated load. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor shall develop full rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop out. All bearings shall be of the ball type and thrust bearings shall be provided where necessary. All bearings shall be provided with suitable seals to confine the lubricant and prevent the entrance of dirt and dust. Motor conduit connections shall be watertight. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement. The motor shall be furnished with a space heater suitable for operation on 120-volt, single-phase, 60-Hz circuit unless the entire actuator is an hermetically sealed, nonbreathing design with a separately sealed terminal compartment which prevents moisture intrusion.

**B. Electric Motor Actuators (AC Reversing Control Type)**

1. **General:** Where indicated, electric motor actuators shall be the ac reversing type complete with local control station with open/close and local/[auto]/[remote] selector switches.

2. Actuator Appurtenances: The actuator for each valve shall be supplied with open and close status lights; open, close and lockout-stop pushbuttons, and all other devices indicated.
3. Starter: The starter shall be a suitably sized amperage rated reversing starter with its coils rated for operation on 120-volt, single-phase, 60-Hz current. A control power transformer shall be included to provide a 120-volt source, unless otherwise indicated. The starter shall be equipped with three overload relays of the automatic reset type. Its control circuit shall be wired as indicated. The integral weatherproof compartment shall contain a suitably sized 120-volt ac, single-phase, 60-Hz space heater to prevent moisture condensation on electrical components.
4. Manufacturers, or equal
  - a. EIM.
  - b. Keystone Controls, Inc.
  - c. Limitorque Corp.

### **PART 3 -- EXECUTION**

#### **3.1 SERVICES OF MANUFACTURER**

- A. Field Adjustments: Field representatives of manufacturers of valves with hydraulic or electric actuators shall adjust actuator controls and limit switches in the field for the required function.
- B. A manufacturer's factory-trained representative shall check and approve the installation before operation. The representative shall operate and test the system in the presence of the Engineer and verify that the equipment conforms to requirements; and shall instruct plant personnel on care and maintenance. The representative shall revisit the job site as often as necessary until all deficiencies are corrected.
- C. Testing, checkout and start-up of the equipment shall be performed under the technical direction of the manufacturer's factory-trained representative. Motor operators shall not be energized without authorization from the manufacturer's representative.
- D. In addition to the above requirements, furnish services of a qualified factory-trained operations and maintenance serviceman to instruct and train operators in the proper care, operation and maintenance of the equipment.

#### **3.2 INSTALLATION**

- A. All valve and gate actuators and accessories shall be installed in accordance with Section 15200 - Valves, General.

- END OF SECTION -





## SECTION 15202 - BUTTERFLY VALVES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 15200 - Valves, General apply to this Section.
- C. The requirements of Section 15201 - Valve Actuators apply to this Section.

#### 1.2 CONTRACTOR SUBMITTALS

- A. The CONTRACTOR shall furnish submittals in accordance with Section 15200 - Valves, General.

#### 1.3 WARRANTY

- A. The butterfly valve manufacturer shall warrant valves 24" and larger, and their operator, against material and workmanship defects for a period not less than 2 years, which commences at final acceptance of the project. Submit the manufacturer's warranty prior to final acceptance.

### PART 2 -- PRODUCTS

#### 2.1 BUTTERFLY VALVES, CLASS 150B AND 250B

- A. General: Butterfly valves for water working pressures up to 250 psi and if not called out otherwise, shall conform to ANSI/AWWA C504 - Rubber Seated Butterfly Valves, subject to the following requirements. Valves shall be of the size and class indicated. Flanged valves shall have ANSI 125-pound flanges for class 150B and ANSI 250-pound flanges for class 250B. Shaft seals shall be designed for use with standard split-V type packing, or other acceptable seal. The interior passage of butterfly valves shall not have any obstructions or stops. The seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats which rely on a high coefficient of friction for retention shall not be acceptable.
- B. Manual Actuators: Actuators shall conform to Section 15201 - Valve Actuators and to ANSI/AWWA C540 - Power Actuating Devices for Valves and Sluice Gates, subject to the following requirements. Unless otherwise indicated, all manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30 inches in diameter and larger.



| C. <u>Valve Tag Nos:</u> | <u>Size</u> | <u>Location</u> | <u>Class</u> | <u>Actuator</u> |
|--------------------------|-------------|-----------------|--------------|-----------------|
| BF-FW-0001A              | 12"         | Well Discharge  | 150B         | Manual          |
| BF-FW-0002A              | 12"         | Well Discharge  | 150B         | Manual          |
| BF-PW-0001A              | 8"          | Pump to Waste   | 150B         | Manual          |

D. Manufacturers, or Equal

1. De Zurik Corporation.
2. Henry Pratt Company.
3. Rodney Hunt Company (24" and larger).

**PART 3 -- EXECUTION**

**3.1 INSTALLATION**

- A. All exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. The installation shall be in accordance with Section 15200 - Valves, General.

- END OF SECTION -

## SECTION 15203 - CHECK VALVES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 15200 - Valves, General apply to this Section.

#### 1.2 CONTRACTOR SUBMITTALS

- A. The CONTRACTOR shall furnish submittals in accordance with Section 15200 - Valves, General.

### PART 2 -- PRODUCTS

#### 2.1 SWING CHECK VALVES (3-INCH AND LARGER)

- A. General: Swing check valves for water, sewage, and general service shall be of the outside lever and spring or weight type, in accordance with ANSI/AWWA C 508-Swing-Check Valves for Waterworks Service, 2 in. through 24 in. NPS, unless otherwise indicated, with full-opening passages, designed for a water-working pressure of 150 psi. They shall have a flanged cover piece to provide access to the disc.
- B. Valve Tag No.'s  

|            |     |                |
|------------|-----|----------------|
| CV-FW-0010 | 12" | Pump Discharge |
|------------|-----|----------------|
- C. Body: The valve body and cover shall be of cast iron conforming to ASTM A 126-Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with flanged ends conforming to ANSI/ASME B 16.1-Cast Iron Pipe Flanges and Flanged Fittings, Class and 25, 125, and 250, or mechanical joint ends, as indicated.
- D. Disc: The valve disc shall be of cast iron, ductile iron, or bronze conforming to ASTM B 62-Specification for Composition Bronze or Ounce Metal Castings.
- E. Seat and Rings: The valve seat and rings shall be of bronze conforming ASTM B 62 OR B 148-Specification for Aluminum-Bronze Castings, or of Buna-N.
- F. Hinge Pin: The hinge pin shall be of bronze or stainless steel.
- G. Manufacturers, or Equal
  - 1. American Flow Control (Darling)
  - 2. Kennedy Valve

3. Mueller Company (Grinell Corporation)

4. Stockham Valves and Fittings

## 2.2 SWING CHECK VALVES (2-1/2-INCH AND SMALLER)

A. General: Swing check valves for water or air in sizes 2-1/2 inches and smaller shall be suitable for a saturated steam pressure of 125 psi and a cold water pressure of 200 psi. They shall have screwed ends, unless otherwise indicated, and screwed caps.

B. Body: The valve body and cap shall be of bronze conforming to ASTM B 61 - Specification for Steam or Valve Bronze Castings, or ASTM B 62 - Specification for Composition Bronze or Ounce Metal Castings, and with threaded ends conforming to ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (inch).

C. Disc: Valves for steam service shall have bronze or brass discs conforming to ASTM B 16 - Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines, and for cold water, oil, and gas service replaceable composition discs.

D. Hinge Pin: The hinge pins shall be of bronze or stainless steel.

E. Manufacturers, or Equal

1. Crane Company

2. Milwaukee Valve Company

3. Stockham Valves and Fittings

4. Wm. Powell Company

## 2.3 PLASTIC BALL CHECK VALVES

A. General: Plastic ball check valves for corrosive fluids, in sizes up to 4 inches, shall be used for vertical upflow conditions only, unless the valves are provided with spring actions.

B. Valve Tag No.'s

BCV-CLS-0001      1"      Chlorine House

C. Construction: The valve bodies and balls shall be of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polyvinylidene fluoride (PVDF), or polypropylene (PP) construction, as best suited for each individual service condition. They shall have unions with socket connections, or flanged ends conforming to ANSI/ASME B16.5-Pipe Flanges and Flanged Fittings, class 150. All seals shall have Viton O-rings and valve design shall minimize possibility of the balls sticking or chattering. The valves shall be suitable for a maximum working nonshock pressure of 150 psi at 73 degrees F.

D. Manufacturers, or Equal

1. ASahi-AMERICA;
2. George Fischer, Inc.
3. NIBCO Inc. (Chemtrol Division);

### **PART 3--EXECUTION**

#### **3.1 GENERAL**

- A. All valves shall be installed in accordance with provisions of Section 15200 - Valves, General.

- END OF SECTION -

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## SECTION 15206 - GATE VALVES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide gate valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 15200 - Valves, General apply to this Section.
- C. The requirements of Section 15201 - Valve and Gate Actuators apply to this Section.

#### 1.2 CONTRACTOR SUBMITTALS

- A. The CONTRACTOR shall furnish submittals in accordance with Section 15200 - Valves, General.

### PART 2 -- PRODUCTS

#### 2.1 GENERAL

- A. All buried valves shall be of the inside screw, nonrising stem type. The valve actuators shall be as indicated, with counter-clockwise opening stems, in accordance with Section 15201 - Valve and Gate Actuators.

#### 2.2 METAL-SEATED GATE VALVES (3-INCH AND LARGER)

- A. Construction: Metal-seated gate valves for water and sewage service shall conform to ANSI/AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service. The valve bodies shall be of stainless steel with flanged ends as indicated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 2 of ANSI/AWWA C500. The design working water pressure shall be 200 psig. The valves may be of the double-disc type for tighter shutoff, or of the solid-wedge type, with rising or nonrising stem.
- B. Valve Tag No.s:
  - GV-FW-0001          12"      Well Discharge
  - GV-FW-0002          6"        Well Discharge
- C. Actuators: Unless otherwise indicated, all gate valves shall have manual actuators in accordance with Section 15201 - Valve and Gate Actuators and as shown on the drawings.
- D. Manufacturers, or Equal

1. American Flow Control
2. Crane Valves
3. Kennedy Valve
4. M & H Valve Company
5. Milwaukee Valve Company, Inc.
6. Mueller Company (Grinnell Corp.)
7. Stockham Valves and Fittings

### 2.3 RESILIENT-SEATED GATE VALVES (3- to 16-inch)

- A. General: Resilient-seated gate valves may be provided in lieu of metal-seated double-disc or solid-disc gate valves, at the discretion of the CONSTRUCTION MANAGER.
- B. Construction: Resilient-seated gate valves shall conform to ANSI/AWWA C 509 – Resilient-Seated Gate Valves for Water and Sewerage Systems. The valves shall be suitable for a design working water pressure of 200 psig, with flanged, bell and spigot, or mechanical joint ends. The valve body, bonnet, and disc shall be of cast iron or ductile iron and the disc or body shall be rubber coated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 2 of ANSI/AWA C 509. The stem, stem nuts, glands, and bushings shall be of bronze, with the stem seal per ANSI/AWWA C 509.
- C. Actuators: Unless otherwise indicated, resilient-seated gate valves shall have manual actuators in accordance with Section 15201 – Valve and Gate Actuators.
- D. Manufacturers, or Equal
  1. American Flow Control.
  2. Kennedy Valve.
  3. M & H Valve Company.
  4. Mueller Company (Grinnell Corp.)
  5. Stockham Valves and Fittings.

## PART 3 -- EXECUTION

### 3.1 GENERAL

- A. All gate valves shall be installed in accordance with the provisions of Section 15200 - Valves, General.



- END OF SECTION -

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## SECTION 15230 - MISCELLANEOUS VALVES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- A. The CONTRACTOR shall provide miscellaneous valves, including accessories and, where designated, operators, complete and operable in accordance with the Contract Documents.

#### 1.2 CONTRACTOR SUBMITTALS

- A. The CONTRACTOR shall furnish submittals in accordance with Section 15200-Valves, General.

### PART 2 -- PRODUCTS

#### 2.1 AIR-VACUUM AND AIR-RELEASE VALVES

- A. Valves shall conform to ANSI/AWWA C512 - Air-Release Air/Vacuum, and Combination Air Valves for Waterworks Service, and the following.
- B. Air and Vacuum Valves: Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled, and allowing air to re-enter while pipelines are being drained. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and all moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi or 250 psi (as applicable) water-working pressure, unless otherwise indicated.
- C. Air-Release Valves: Air-release valves shall vent accumulating air while system is in service and under pressure and be of the size indicated and shall meet the same general requirements as specified for air and vacuum valves except that the vacuum feature will not be required. They shall be designed for a minimum water-working pressure of 150 psi or 250 psi (as applicable), unless otherwise indicated.
- D. Combination Air Valves: Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. They shall have the same general requirements as for air and vacuum valves.
- E. Vacuum Relief Valves, Class 300: Vacuum relief valves shall be capable of allowing air to enter the surge tanks while they are being drained. Valve shall be globe-type body with flanged end per ANSI B 16.1, Class 250. Provide steel hood. Internal valve plug and seat shall be bronze per ASTM B 485, Alloy 836 or brass per ASTM B 584 with Buna-N seal. Plug shall be center-guided at both ends and shall be normally closed by means of a stainless steel spring and shall open when the vacuum/differential pressure exceeds 0.25 Psi.

F. Manufacturers, or Equal

1. Apco Willamette Valve & Primer Corporation.
2. Golden-Anderson Valve Division (GA Industries, Inc.).
3. Val-Matic (Valve and Manufacturing Corporation). stries).

2.2 CORPORATION STOPS

A. Unless otherwise indicated, corporation stops shall be made of solid brass for key operation, with screwed ends with corporation thread or iron pipe thread, as required.

B. Manufacturer, or Equal

1. Ford Meter Box Company.
2. James Jones Company (Watts Regulator Co.).
3. Mueller Company (Grinnell Corporation).

2.3 SOLENOID VALVES

A. Solenoid valves shall be of the size, type, and class shown and shall be designed for not less than 150 psi water-working pressure unless otherwise indicated. Valves for water, air, or gas service shall have brass or bronze body with screwed ends, stainless steel trim and spring, Teflon or other resilient seals with material best suited for the temperature and fluid handled. Solenoid valves in corrosive environment shall have stainless steel bodies. For chemicals and all corrosive fluids, solenoid valves with Teflon bodies and springs or other suitable materials shall be used. Enclosures shall be NEMA-rated in accordance with the area designations of Section 16050 – Electrical General Provisions. All coil ratings shall be for continuous duty. For electrical characteristics see Electrical Drawings or Specifications.

B. Manufacturers, or Equal

1. ASCO

**PART 3 -- EXECUTION**

3.1 INSTALLATION

- A. All valves shall be installed in accordance with the Manufacturer's printed recommendations.
- B. All air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly supported, and installed in such a way as to avoid splashing and wetting of floors.

-END OF SECTION-

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## SECTION 16000

### GENERAL ELECTRICAL REQUIREMENTS

#### PART 1 - GENERAL

##### 1.01 SUMMARY

###### A. Section Includes

1. Work and materials necessary for erecting a complete electrical and instrumentation system, tested and ready for continuous use.

###### B. Related Sections

1. Division 0 Bid Requirements, Contract Forms, and Contract Conditions
2. Division 1 General Requirements
3. Division 2 Site Construction
4. Division 3 Concrete
5. Division 9 Finishes
6. Division 11 Equipment
7. Division 13 Special Construction
8. Division 15 Mechanical
9. Division 17 Instrumentation

##### 1.02 DEFINITIONS

- ###### A. The term "Provide" means "Furnish and Install".

##### 1.03 SYSTEM DESCRIPTION

###### A. Design Requirements

1. If any contradictions, contrasts, or inconsistency appears, the most strict criteria noted and the collective requirements in any and all of the project documents shall apply.

##### 1.04 SUBMITTALS

###### A. Intent

1. Organize work so that a complete electrical, instrumentation, and control system for the facility will be provided and will be supported by accurate shop drawings, record drawings, and O&M manuals.
2. Submit detailed shop drawings and data prepared and organized by the suppliers. Provide quantity of submittal sets in accordance with the requirements of Division 1.
3. Submittals shall be neatly grouped and organized by specification section number, and sub-section. Related information shall be highlighted, and the specific product shall be marked. All submittals shall be complete, and presented in one package.



Incomplete submittals will be returned without review. If a portion of the project requires a fast track schedule, that portion only may be submitted earlier under a separate cover letter.

4. Work performed or equipment provided without engineer approved submittals is done at contractor's risk. Cost to re-work or re-supply will be born solely by the contractor.

B. Product Data

1. A complete list of the equipment and materials, including the manufacturer's name, product specification, descriptive data, technical literature, performance charts, catalog cuts, installation instructions, and spare part recommendations for each different item of the equipment specified. The above shall clearly show all the specified requirements as described in the Specifications including but not limited to specific UL and NEMA rating, technical capabilities, test result verifications, and acceptance letters.
2. Submittals not in compliance with the specifications must include the following information:
  - a. Reason for non-compliance or variance
  - b. Calculations and drawings for redesign of related components including detail drawings showing internal and assembly details, with installation instructions.
  - c. Proposed layout showing any modifications or exceptions to related work made necessary by this work, with calculations and drawings showing such modifications or exceptions.

C. Shop Drawings

1. Drawings containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will operate as intended. Drawings shall show proposed layout, anchoring, support, and appurtenances of equipment, and equipment relationship to other parts of the work including clearances for maintenance and operations.

D. Utility Coordination

1. Submit copies of service entrance shop drawings to the utility, per utility submittal requirements, prior to submittal to the Engineer. Obtain written approval from the power utility company that the service entrance equipment is acceptable prior to release the order to the supplier for fabrication. Provide a copy of the approval letter from the utility with the submittal.

E. Closeout Submittals

1. Provide "Record Drawings" of the electrical, control, and instrumentation work to include:
  - a. Step-by-step procedure manuals for the installation, operation start-up, and maintenance of the equipment.
  - b. Installation, operating, troubleshooting, and maintenance and overhaul instructions in complete detail.

- c. Possible breakdowns and repairs, and troubleshooting guides, as well as simplified wiring and control diagrams of the system installed. This shall provide the Owner with comprehensive information on all systems and components to enable operation, service, maintenance and repair.
  - d. Exploded or other detailed views of all equipment, devices, assemblies, and accessory components shall be included, together with complete parts lists and ordering instructions.
2. Provide an "As Built" set of Plans to Owner. Maintain at all times a marked up set of Plans showing the following information:
- a. Actual installed circuit numbers, conduit sizes, cable tray routing, number of conductors, conductor sizes (larger than #12 AWG), and all other deviations from the design Plans.
  - b. Underground conduit, duct banks, and concealed items dimensioned on the Plans from permanent, visible, building features.
  - c. Actual motor size, starter size, and overload heater size, along with all other protective equipment for all 480 V and 4160 V motor circuits.
  - d. Conductor identification and panel schedules.

#### 1.05 QUALITY ASSURANCE

##### A. Regulatory Requirements

1. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations, codes, and standards, of the following:
- a. National Electrical Code (NEC)
  - b. State and local codes
  - c. Institute of Electrical and Electronic Engineers (IEEE)
  - d. American National Standards Institute (ANSI)
  - e. American Society for Testing and Materials (ASTM)
  - f. Insulated Cable Engineers Association (ICEA)
  - g. National Electrical Manufacturers Association (NEMA) Standards
  - h. Federal Occupational Safety and Health Act (OSHA)
  - i. National Fire Protection Association (NFPA)
  - j. National Electrical Testing Association (NETA)

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Electrical panels, switchgear, motor control centers, and other electrical equipment, shall be shipped in sealed dust and moisture proof plastic sheet enclosures, and the seal maintained until units are installed. Said units shall be new and free of any dirt, dust, water, grease, rust, damaged parts or components.

#### 1.07 PROJECT/SITE CONDITIONS

- A. Verify site conditions before bidding or performing work.

1.08 SCHEDULING

- A. Maintain a work schedule showing work to be performed, sequence of work, major milestones, and manpower loading. Coordinate schedule requirements with other trades. Provide adequate staff to perform the work in the time required by the schedule.

1.09 SYSTEM STARTUP

- A. After installation and testing of all electrical and instrumentation equipment and systems, energize all equipment and leave ready for continuous operation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers and model numbers shown on Plans or listed in the specifications are intended to establish a minimum standard of quality and acceptability.

2.02 MATERIALS

- A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged materials, equipment, and parts, are not considered to be new and unused, and will not be accepted.

2.03 MANUFACTURED UNITS

- A. The fabricator of major components and manufactured units, such as distribution panel boards, switchgear, and motor control centers, shall also be the manufacturer of the major devices therein.
- B. Electrical equipment provided with mechanical equipment assemblies shall be in compliance with this specification.

2.04 EQUIPMENT

- A. Minimum sizes of equipment, and electrical devices, are indicated but it is not intended to show every offset and fitting, nor every structural or mechanical difficulty that will be encountered during the installation of the work.
- B. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 60 degrees C, and specifically rated for the altitude indicated on the Plans. Provide air conditioning to meet the manufacturers' operating temperature for electrical equipment not rated for operation at that temperature.

- C. When applicable, the material used in the performance of the electrical work shall be listed by the Underwriters' Laboratories, Inc. (UL) for the class of service for which they are intended.
- D. Provide nameplates where indicated elsewhere in these specifications or on the Plans. Nameplates shall be black laminate with white letters and fastened to the various devices with round head stainless steel screws. Provide nameplates for each disconnecting means for service, feeder, branch, or equipment conductors, indicating its purpose.

## 2.05 FABRICATION

- A. Shop Assembly
  - 1. Equipment assemblies, such as Service Entrance Sections, Switchgear, Switchboards, Control and Distribution Panels, and other custom fabricated electrical enclosures shall bear a UL label as a complete assembly. The UL label on the individual components making up the assembly will not be considered sufficient to meet the present requirement. Whenever a generic UL label does not apply for the assembly, a serialized UL label shall be affixed to the assembly, and the serial number shall be submitted with the assembly record shop drawings.
  - 2. Custom fabricated electrical control panels, and enclosures, shall bear a UL label affixed by a local UL inspector.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Site Verification of Conditions
  - 1. Verify site conditions before bidding or performing work.

### 3.02 INSTALLATION

- A. Coordinate work with other trades and with certified vendor shop drawing submittals.
- B. Provide equipment in accordance with the manufacturers' requirements.
- C. Identify each conductor as required by the Contract Documents.
- D. Equipment Access:
  - 1. Install equipment so it is readily accessible for operation and maintenance.
  - 2. Equipment shall not be blocked or concealed.
  - 3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.
- E. Equipment shall be installed plumb, square and true with the building construction, and shall be securely fastened.

- F. Outdoor wall-mounted equipment, and indoor equipment mounted on earth, or water bearing walls, shall be provided with corrosion-resistant spacers to maintain 1/4-inch separation between the equipment and the wall.
- G. Arrange for the building in of equipment during structure construction. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs, and other openings, as required to allow installation of equipment after structure construction is complete.
- H. Verify that equipment will fit support layouts indicated.
- I. Screen or seal all openings into outdoor equipment to prevent the entrance of rodents and insects.
- J. Equipment fabricated from aluminum shall not be imbedded in earth or concrete.
- K. Provide all necessary anchoring devices and supports.
  - 1. Use supports as detailed on the Plans and as specified.
  - 2. Supports and anchoring devices shall be rated and sized based on dimensions and weights verified from approved equipment submittals.
  - 3. Hardware shall be stainless steel.
  - 4. Do not cut, or weld to, building structural members.
  - 5. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.
- L. Verify exact rough-in location and dimensions for connection to electrical items furnished by others.
  - 1. Obtain shop drawings from those furnishing the equipment.
  - 2. Proceeding without proper information may require the Contractor to remove and replace work that does not meet the conditions imposed by the equipment supplied.
  - 3. Provide sleeves wherever openings are required through new concrete or masonry members. Place sleeves accurately and coordinate locations with the Engineer.
  - 4. Do not endanger the stability of any structural member by cutting, digging, chasing, or drilling and shall not, at any time, cut or alter the work without the Engineer's written consent.
    - a. Provide additional reinforcing if required.
    - b. Use proper tools and methods to cut, core drill, or make other penetrations.
    - c. Restore walls, ceilings, or floors to their original condition.
- M. Provide concrete foundations or pads required for electrical equipment as indicated or specified.
  - 1. Provide a 4-inch concrete housekeeping pad for floor mounted electrical equipment. Pour on top of the finished floor or slab. Drill existing slab and epoxy rebar to anchor housekeeping pad in place.

- N. Do not use equipment that exceeds the indicated dimensions except as approved in writing by the Engineer.
- O. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.
- P. Work indicated on the Plans is approximately to scale, but actual dimensions and detailed Plans should be followed as closely as field conditions permit. Field verification of scale dimensions on Plans is governed by field conditions. Installation of systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination.
- Q. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of the Engineer for clarification, prior to purchasing and installing equipment.
- R. Adjust the alignment of equipment and conduit to accommodate architectural changes or to avoid work of other trades.
- S. Provide parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the requirements of these Contract Documents.
- T. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.
- U. Lay out and install electrical work prior to placing floors and walls. Provide sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.
- V. Provide inserts and hangers required to support conduits and other electrical equipment. Coordinate inserts and hangers with other trades. Replace inserts, hangers, sleeves, or other mounting hardware which are improperly placed.
- W. Perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. Use core drills to make circular holes.
- X. ELECTRICAL UTILITY
  - 1. Coordinate the electrical utility work with the electrical utility company. Note the additional submittal requirements under "SUBMITTALS – Utility Coordination" in Part 1 of this specification. Provide equipment and material required to bring electrical service to the service location in conformance with the electrical utility requirements. Provide the following for the electrical utility company's primary



(from utility power line to the utility transformer) and secondary (from utility transformer to the service) electrical lines in accordance with the electrical utility company's specifications and requirements:

- a. Conduits (verify quantity and sizes)
- b. Trenching, backfill, and compacting (verify trench size(s), backfill material, and compaction percentage requirements)
- c. Concrete pad(s) (for pad mounted transformer(s))
- d. Cable protection along the vertical drop at the utility company's pole (if pole mounted transformer(s))
- e. Other items required by the power utility company's specifications

#### Y. TEMPORARY POWER

1. Provide and maintain temporary power and lighting systems needed for construction. Work shall include:
  - a. Weatherproof panel(s) for the Contractor's main breakers and distribution system.
  - b. Conduit and cable.
2. Use ground fault interrupting equipment.
3. Connections shall be watertight, with wiring done with Type SO portable cable.
4. Route and support cables to avoid mechanical damage.
5. Remove temporary power equipment and devices upon completion of construction.

#### Z. CORROSION PROTECTION

1. Wherever dissimilar metals, except conduit and conduit fittings, come in contact, the Contractor shall isolate these metals, as required, with neoprene washers, 9 mil polyethylene tape, or gaskets. Where fastening conduit, electro plated, or equivalent fasteners and stainless steel bolts shall be used.

### 3.03 REPAIR/RESTORATION

- A. Repair damage caused by construction or demolition work to restore damaged areas to original condition.
- B. Factory finishes damaged during shipping, or construction, shall be restored to original new condition. Rust shall be removed, and bare metal surfaces shall be primed and painted to match the original surrounding finish.

### 3.04 FIELD QUALITY CONTROL

#### A. Site Tests

1. The electrical work shall be free from improper grounds and from short circuits. Visually compare the conductor connections with connection diagrams. Perform individual circuit continuity checks using electrical circuit testers. Demonstrate proper operation of the energized electrical and mechanical devices. Correct any wiring deficiencies.



3.05 ADJUSTING

- A. Calibrate and set all adjustable electrical equipment including circuit breakers, motor circuit protectors, overload relays. Align photo cells and lights to achieve desired effects.

3.06 CLEANING

- A. Relays, starters, circuit breakers, switches, contacts, insulators, mechanisms, and buses shall be free of dust, dirt, oil, moisture, metal shavings, and other debris before testing and energizing equipment. Vacuum and wipe down inside and outside of electrical enclosures and control panels.

3.07 PROTECTION

- A. Once equipment is installed, it shall be protected at all times with plastic sheet covers until the area is free of dirt, dust, paint spray, water, and other trades. Provide heat to eliminate condensation.

End of Section

## SECTION 16111

### CONDUITS

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. Furnish and install conduits as required, and as shown on the Drawings. Materials employed shall be as shown on the Drawings.

##### 1.02 SUBMITTALS

- A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.
- B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work.
- C. Proposed routing of conduits buried under floor slabs-on-grade.
- D. Identify conduit by tag number of equipment served or by circuit schedule number.
- E. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served or by circuit schedule number.
- F. Proposed location and details of construction for openings in slabs and walls for raceway runs.
- G. Refer to Section 16000 for further submittal requirements.

##### 1.03 REFERENCES

- A. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc-Coated.
- B. National Electric Manufacturers Association (NEMA): RN-1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.
- C. Underwriters Laboratories Inc. (UL):
  - 1. 1, Flexible Metal Conduit.
  - 2. 6, Rigid Metal Conduit.
  - 3. 360, Liquid-Tight Flexible Steel Conduit.
  - 4. 467, Grounding and Bonding Equipment.

5. 514, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
6. 651, Schedule 40 and 80 Rigid PVC Conduit.
7. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
8. 884, Underfloor Raceways and Fittings.
9. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

## PART 2 - PRODUCTS

### 2.01 RACEWAYS

- A. Exposed conduit in an unclassified or hazardous area shall be galvanized rigid steel (GRS) unless specifically indicated otherwise on the Drawings. Conduits in the corrosive areas shall be PVC coated GRS unless otherwise indicated. Underground and/or concrete encased conduits shall be PVC, unless otherwise indicated. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than one inch.
- B. Condulet type fittings shall be Crouse-Hinds, Appleton, or equal with wedge nut covers. All condulets located outdoors or in wet locations shall be weathertight.
- C. In unclassified areas, flexible conduit shall be grounding type, weatherproof, corrosion resistant, and watertight.
- D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout.
- E. Expansion fittings shall be OZ type AX with jumper for exposed locations and type DX at structural expansion joints, Spring City, or equal. Conduits shall have expansion fittings in accordance with NEC.
- F. The conduits and fittings shall be supported per NEC requirements as a minimum.

### 2.02 GALVANIZED RIGID STEEL (GRS)

- A. Conduit and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc bichromate, in accordance with ANSI C80.1 standards, as manufactured by Jones & Laughlin Steel Corporation, Allied Tube & Conduit Corporation, Triangle PWC, or equal.
- B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. A half lapped rapping of 20 mil PVC based corrosion protection tape shall be used.

2.03 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

- A. PVC coated GRS conduit shall be installed where shown on the Drawings or elsewhere specified and shall conform to NEMA RN-1 and ANSI C80.1 standards.
- B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A Polyvinyl Chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 0.040-inch (40 mil).
- C. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 1-1/2 inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be a minimum of 0.040-inch (40 mil).
- D. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be completely interchangeable. The inside of conduit bodies shall remain undisturbed in the processing.
- E. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.
- F. Conduit straps shall be PVC coated or stainless steel.
- G. PVC coated conduit and fittings shall be as manufactured by Kor Kap Corporation, Occidental Coating Company, Rob-Roy, or equal.
- H. PVC coated flexible conduits shall be liquid and vaportight and manufactured in accordance with UL 360 standards.

2.04 RIGID NONMETALLIC - PVC

- A. Where specifically indicated on the Drawings, or elsewhere specified, conduit may be high density Schedule 40, 90 degrees C, heavy-duty PVC. The conduit shall be manufactured from virgin polyvinyl chloride compound which meets ASTM D1784, NEMA TC-2, ANSI C33.91, and UL 651 standards. Smoke emissions shall be limited to less than 6 grams per 100 grams of material tested.

- B. Where conduit concrete encasement is indicated on the Drawings, conduit supports shall be installed at five foot intervals. PVC conduit shall be manufactured by Carlon, Triangle Conduit & Cable, or equal.

#### 2.05 INTERMEDIATE METAL CONDUIT

- A. Conduit and couplings shall be galvanized intermediate metal conduit manufactured in accordance with UL 1242 and as manufactured by Allied Tube & Conduit Corporation, Jones & Laughlin Steel Corporation, or equal.
- B. Intermediate metal conduit shall not be buried without concrete encasement. Threadless couplings and connectors shall not be used.

#### 2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Liquidtight flexible metal conduit shall be liquid and vaportight, oil and ultraviolet ray resistant and manufactured in accordance with UL 360 standards. Liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90 degrees Celsius.
- B. For corrosive locations, liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors.
- C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1 1/2 " or larger. Flexible conduit and connectors for 1 1/4" and smaller shall be listed for grounding.
- D. Connectors for liquidtight flexible conduit shall be galvanized, furnished with a sealing ring and locknut, and suitable for wet locations.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the Engineer.
- B. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.

- C. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be uniform and symmetrical. Changes in direction shall be made with long radius bends, or with fittings of the conduit type.
- D. Conduit runs in buildings and structures shall be exposed except as specifically noted, or accepted by the Engineer.
- E. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.
- F. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to motors from junction boxes, or control equipment.
- G. Conduit runs on water-bearing walls shall be supported one inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.
- H. Conduit shall be thoroughly reamed to remove burrs. IMC or GRS shall be reamed during the threading process, and Rigid Nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads. Bushings and lock nuts or hubs shall be used at conduit termination's. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the Engineer. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped and shall contain a suitable pull string.
- I. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.
- J. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.
- K. After installation of complete conduit runs 2 inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used.
- L. Expansion fittings shall be installed across all expansion joints and at other locations where necessary to compensate for thermal expansion and contraction.
- M. Provide trenching, backfill, and compaction for conduits installed underground.

- N. Unless approved in advance by the Engineer, all conduits which transition from underground to aboveground will utilize galvanized rigid steel conduit for the bend from horizontal to vertical and for the extension above the ground. Factory 90 degree GRS bends shall be used. GRS bends and conduits shall be half lapped with 20 mil PVC tape in non-corrosive areas and shall be PVC coated rigid steel in corrosive areas. Tape wrapping shall extend a minimum 6 inches above top of slab or above finished grade.
- O. Liquid tight flexible metallic conduit 1-1/2 inch and larger shall be provided with grounding style bushings and shall have an external ground wire sized and installed in accordance with the NEC.

End of Section



## SECTION 16123

### 600 VOLT CLASS CABLE

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This section covers the furnishing and installation of 600 Volt Class cables and conductors, terminations and splicing, and pulling lubricants.

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

##### 1.03 REFERENCES

- A. Insulated Cable Engineers Association/National Electrical Manufacturers Association (ICEA/NEMA):
  - 1. S-68-516/WC 8, ethylene-propylene rubber-insulated wire and cable for the transmission and distribution of electrical energy.
  - 2. S-61-402/WC 5, thermoplastic-insulated wire and cable for the transmission and distribution of electrical energy.
  - 3. S-66-524/WC 7, cross-linked thermosetting-polyethylene-insulated wire and cable for transmission and distribution of electrical energy.
- B. Underwriters Laboratory, Inc.
  - 1. 44, rubber insulated wires and cables.
  - 2. 83, thermoplastic-insulated wires and cables.
  - 3. 486A, wire connectors and soldering lugs for use with copper conductors.
  - 4. 486B, wire connectors for use with aluminum conductors.
  - 5. 510, insulating tape.
- C. National Electric Code

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTED MANUFACTURERS

- A. Conductors and Multi Conductor Cables (MCC), subject to compliance with Contract Documents, the following manufacturers are acceptable: American Insulated Wire Corporation, Cablec Corporation, Okonite Company, Southwire Company, or equal.

## 2.02 CONDUCTORS

- A. Wire sizes shall be American Wire Gauge (AWG) sizes with Class B stranded construction. Number 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape. Conductors sized No. 1 and larger shall be Type 2, rated for 90 degrees C. All circuit conductors, #6 or smaller shall be "THWN" stranded copper. All other conductors shall be "XHHW-2" stranded copper.
- B. Individual or multiple conductor cables for power, control, and alarm circuits of 480 volts or less shall be insulated for not less than 600 volts and shall have insulation type as indicated on the Drawings. "THHW" shall conform to ICEA S-61-402/NEMA WC 5 and UL 83 and "XHHW" shall conform to ICEA S-66-524/NEMA WC 7 and UL 44. Where wire size is not indicated, they shall be of the size required by the NEC, except that no wire external to panels and motor control centers shall be less than No. 12 AWG, unless specifically noted on the Drawings. Panel control wiring shall not be less than No. 14 AWG.
- C. All wiring shall be as indicated on the Drawings. Wires shall be new and shall be soft drawn copper with not less than 97 percent conductivity. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's name permanently marked on the outer covering at not more than 2-foot intervals. All wires shall conform to the latest Standards of the ASTM, and ICEA, and shall be tested for their full length by these Standards. Insulation thickness shall be not less than that specified by the National Electrical Code.
- D. Power conductors for lighting and receptacles only may utilize "THWN" solid conductors.

## 2.03 TERMINATIONS AND SPLICES

- A. Cable shall be rated 600 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splicing shall join conductors mechanically and electrically to provide a complete circuit prior to installation of insulation.
- B. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, Type I, Class 1, Grade B, Style G, or Type II, Class 1 of FS W-S-610 and conforming to the applicable requirements of UL 486A.
- C. Splices in wires No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, Type II, Class 2 of FS W-S-610, conforming to the applicable requirements of UL 486A and UL 486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket.

- D. Insulated conductor splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.
- E. Bare conductor splices in wet locations or below grade shall be of the exothermic type.

#### 2.04 PULLING LUBRICANT

- A. All cables shall be properly coated with pulling compound such as ClearGluid, Aqua Gel, Polywater, or equal before being pulled into conduits so as to prevent mechanical damage to the cables during installation. "Yellow 77" is not acceptable.
- B. Other lubricants to be substituted must be accompanied by a statement from the cable manufacturer as to its acceptable use with the cable being installed.

#### 2.05 IDENTIFICATION

- A. All conductors shall be numbered with "tube sleeve" type tags with heat impressed letters and numbers.
- B. Color code all wiring as follows:
  - 1. Lighting and power wiring:

| CONDUCTOR | <u>120/208 VAC</u> | <u>480VAC</u> | <u>24V DC</u>            | <u>120 VAC Control/ POWER</u> |
|-----------|--------------------|---------------|--------------------------|-------------------------------|
| Phase 1   | Black              | Brown         | Blue                     | Red                           |
| Phase 2   | Red                | Orange        | (-) Blue w/ white stripe |                               |
| Phase 3   | Blue               | Yellow        |                          |                               |
| Neutrals  | White              | White or Gray |                          | White                         |

- 2. Color code ends of feeder phase conductors only.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. The pulling tension and side-wall pressures, as recommended by the cable manufacturer, shall not be exceeded.
- B. As far as practical, all circuits shall be continuous from origin to termination without splices in intermediate pull boxes. Sufficient slack shall be left at the termination to make proper connections. In no case shall a splice be pulled into the conduit. Conductor splicing shall not be permitted without the Engineer's approval.

- C. Install all cables in conduit.
  - D. Each feeder and branch circuit shall be installed in its own individual conduit unless combining feeder and branch circuits is permitted as defined in the following:
    - 1. As specifically indicated on the Drawings.
    - 2. For lighting, multiple branch circuits may be installed in a conduit as allowed by the NEC and with the wire ampacity derated in accordance with the requirements of the NEC. Conduit fill shall not exceed the limits established by the NEC.
    - 3. When field conditions dictate and written permission is obtained from the Engineer.
  - E. Feeder and branch circuits shall be isolated from each other and from all instrumentation and control circuits.
  - F. Control circuits shall be isolated from all other feeder, branch and instrumentation circuits, except as noted below.
    - 1. 12 V DC, 24 V DC and 48 V DC control circuits may be combined in common conduit.
    - 2. 125 V DC control circuits shall be isolated from all other DC and AC control circuits.
    - 3. 120 V AC control circuits shall be isolated from all DC control circuits.
  - G. Make splices only at pull or junction boxes.
    - 1. Crimp or indented-type connectors are not allowed, except for control circuits landed on terminal strips.
- 3.02 TESTING
- A. In accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

## SECTION 16124

### INSTRUMENTATION CLASS CABLE

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This section covers cable use for process signal and controls.

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with Contract Documents, the instrumentation cable shall be as manufactured by Belden, Okonite, or equal.

##### 2.02 INSTRUMENTATION CABLE

- A. Instrument cable shall be Type TC, and have the number of individually shielded twisted pairs indicated on the Drawings and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog signals.
- B. The jacket shall be flame retardant with 90 degrees C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.
- C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.
- D. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100 percent coverage. All group shields shall be completely isolated from each other.

#### PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Feeder and branch circuits shall be isolated from each other, and from instrumentation and control circuits. Instrumentation cables shall be installed in separate raceways from other cables and wiring. This includes portions running through manholes. Instrumentation cable shall be continuous between instruments or between field devices and instrument enclosures. There shall be no intermediate splices or terminal boards, unless otherwise shown on the Drawings.
- B. Maintain electrical continuity of the shield when splicing twisted shielded pair conductors. Drain wires shall be terminated inside enclosures at grounded terminal blocks. Only one end of each instrument loop cable drain wire shall be grounded. Ground drain wire of shielded conductors at one end only.
- C. Terminate instrumentation and control wiring, including spare wires, at control panels and motor control centers on terminal boards mounted inside the equipment.
  - 1. Contractor shall supply terminal boards as required.
  - 2. Do not field wire directly to devices.

End of Section

## SECTION 16130

### OUTLET, PULL, AND JUNCTION BOXES

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. Section Includes:
  - 1. Outlet, pull and junction boxes.
- B. Related Sections include but are not necessarily limited to:
  - Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
  - Division 1 - General Requirements.
  - Section 16000 - Electrical: Basic Requirements.
  - Section 16111 - Conduits.
  - Section 16141 - Wiring Devices.
  - Section 16170 - Grounding.

##### 1.02 QUALITY ASSURANCE

- A. Referenced Standards:
  - 1. Refer to Section 16000.

##### 1.03 SUBMITTALS

- A. Shop Drawings:
  - 1. Refer to the Contract Documents and Section 16000.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. See Section 16000.

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
  - 1. Galvanized steel boxes:
    - a. Appleton Electric Co.
    - b. Steel City.
    - c. Raco.
  - 2. Sheet metal boxes for non-classified areas:
    - a. Hoffman Engineering Co.
  - 3. Corrosion-resistant boxes:

- a. Hoffman Engineering Co.
- b. Crouse-Hinds.
- 4. Hazardous location boxes (Class I, II & III):
  - a. Appleton Electric Co.
  - b. Crouse-Hinds.
  - c. Killark.
  - d. O-Z/Gedney.
- 5. Raintight and watertight boxes:
  - a. Appleton Electric Co.
  - b. Crouse-Hinds.
- 6. Terminal boxes:
  - a. Hoffman Engineering Co.
- 7. Boxes in sidewalk:
  - a. Appleton Electric Co.
  - b. Crouse-Hinds.
  - c. O-Z/Gedney.
- 8. Boxes in earth:
  - a. Carlon Electric Products.
- 9. Exposed switch and receptacle boxes:
  - a. Appleton Electric Co.
  - b. Crouse-Hinds.
  - c. Killark.

B. Submit requests for substitution in accordance with Specification Section 01630.

## 2.02 MATERIALS

A. Pull and Junction Boxes for Offices and other Dry Architecturally Finished Areas:

- 1. Material: 14 GA, galvanized steel.
- 2. Concentric knockouts on all four sides.
- 3. Flat cover fastened with screws.
- 4. NEMA 1 classification.
- 5. UL listed.

B. Pull and Junction Boxes for General Use Unclassified Areas Suitable for NEMA 12 Enclosures:

- 1. Material: 14 GA galvanized steel with seams continuously welded, ground smooth and no knockouts.
- 2. Zinc rich coating on all seams.
- 3. Stainless steel captivated cover screws threaded into sealed wells.
- 4. Flat door with oil resistant gasket.
- 5. NEMA 12 classification.
- 6. UL listed.

C. Pull and Junction Boxes for Wet Areas:

- 1. Material: 14 GA steel with polyester powder coating inside and out over phosphatized surfaces.



2. Seams continuously welded, ground smooth, no knockouts.
3. Stainless steel clamps on four sides.
4. Flat cover with oil resistant gasket.
5. NEMA 4 classification.
6. UL listed.

D. Pull and Junction Boxes for Corrosive Areas:

1. Material: 14 GA steel with powdered epoxy resin coating inside and out or fiberglass-reinforced polyester material.
2. Steel boxes:
  - a. Seams continuously welded, ground smooth, no knockouts.
  - b. Rolled lip around all sides.
  - c. Hinged door.
  - d. Captivated stainless steel door screws.
  - e. Flat door with oil-resistant gasket.
3. Fiberglass-reinforced polyester boxes:
  - a. Hinged door with latch and lockout.
  - b. Neoprene door gasket.
  - c. Grounding bushing(s).
4. NEMA 4X classification.
5. UL listed.

E. Pull and Junction Boxes for Hazardous Areas:

1. Material: Cast gray iron alloy or copper-free cast aluminum.
2. Drilled and tapped openings or tapered threaded hub equipped.
3. Flat bolted-down or threaded cover with neoprene gasket.
4. Stainless steel hex head screws.
5. Explosion proof, UL listed for Class 1 Groups C and D.

F. Pull and Junction Boxes for Sidewalks:

1. Cast-iron box and cover, hot-dip galvanized.
2. Flange for flush mounting.
3. Checkered cover with neoprene gasket, pry bar slots and stainless steel screws.
4. UL listed.
5. Drilled and tapped holes.
6. Watertight NEMA 4 classification.

G. Large Pull and Junction Boxes (100 CU IN and larger):

1. Located in offices and other dry architecturally finished areas where EMT is utilized:
  - a. NEMA 1 gasketed without knockouts.
2. Located in general use areas:
  - a. NEMA 12 construction:
    - 1) Welded steel.
    - 2) Furnished with gray enamel inside and out over phosphatized surfaces.
3. Located in wet and corrosive areas:
  - a. NEMA 4X with stainless steel screws.

- b. Type 304 L welded stainless steel:
- 4. Constructed of 14 GA steel with seams continuously welded, ground smooth, no knockouts.
- 5. Rolled lip around all sides.
- 6. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
- 7. Split covers when heavier than 25 LBS.
- H. Terminal Boxes:
  - 1. Galvanized 16 GA steel box provided with plain blank screw cover, subpanel, and terminal points.
  - 2. Refer to Drawing for dimensions and number of terminals.
- I. Fiberglass Cable-Pulling Enclosure:
  - 1. Use: Access points to facilitate pulling of electrical cables in buried conduit runs.
  - 2. Size and quantity: As shown on Drawings.
  - 3. Type: Rectangular fiberglass composite, suitable for direct burial pedestrian traffic on top, -50 DegF, chemical, sunlight, and weather resistant.
  - 4. Provide matching top with "ELECTRIC" logo.
- J. Outlet Boxes:
  - 1. Use: Installation of wiring devices.
  - 2. Boxes for exposed wiring:
    - a. Cadmium plated, cast, ferrous metal, with threaded hubs.
  - 3. Boxes for concealed wiring:
    - a. Code gage, hot-dip galvanized steel.
    - b. Include bar hangers for metal stud partitions.
    - c. Provide barriers between switches in boxes with 277 V switches on opposite phases.
    - d. Use extension and plaster rings where required.
    - e. Provide grounding screw.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Use locknut and bushing for boxes in non-classified areas.
- B. Use cast metal boxes with threaded conduit hubs in hazardous areas.
- C. Use Type FS and FD boxes in wet areas and where exposed rigid steel conduit is required.
- D. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
- E. Use outlet boxes sized to accommodate quantity of conductors enclosed.
- F. Use boxes sized to accommodate conduit tying into box.

- G. Install pull boxes or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
  - 1. Make covers of boxes accessible.
- H. Install pull boxes or junction boxes rated for the area classification.
- I. Install rigid conduit squarely into boxes which do not have hubs or are drilled and tapped.
  - 1. Install with locknut on the outside and bushing on inside.
- J. Install conduit into boxes with hubs, or that are tapped, using thread lubricant.
- K. Do not use back-to-back boxes on this Project.
- L. Seal all points of conduit entry into fiberglass cable-pulling enclosures for a waterproof installation.
- M. Support outlet boxes for incandescent fixtures and other ceiling-mounted devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.

End Of Section

## SECTION 16141

### WIRING DEVICES

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. Section Includes:
  - 1. Light switches, receptacles, device plates, dimmers, plug-in strips and tele-power poles.
- B. Related Sections include but are not necessarily limited to:
  - Division 0 -Bidding Requirements, Contract Forms, and Conditions of the Contract.
  - Division 1 - General Requirements.
  - Section 16000 - Electrical: Basic Requirements.
  - Section 16130 -Outlet, Pull, and Junction Boxes.
  - Section 16170 - Grounding.

##### 1.02 QUALITY ASSURANCE

- A. Referenced Standards:
  - 1. Refer to Section 16000.

##### 1.03 SUBMITTALS

- A. Shop Drawings:
  - 1. Refer to the Contract Documents and Section 16000.

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
  - 1. Light switches (except explosion proof):
    - a. Hubbell.
    - b. Slater.
    - c. P&S.
    - d. Arrow Hart.
    - e. General Electric.
    - f. Leviton.
  - 2. Explosion proof light switches:
    - a. Crouse-Hinds.
    - b. Appleton Electric Co.
    - c. Killark.

3. Door switches:
  - a. General Electric.
  - b. Slater.
  - c. P&S.
  - d. Arrow Hart.
  - e. Micro-switch.
4. Receptacles (except explosion proof):
  - a. Hubbell.
  - b. Slater.
  - c. P&S.
  - d. Arrow Hart.
  - e. General Electric.
  - f. Leviton.
5. Explosion proof receptacles:
  - a. Crouse-Hinds.
  - b. Appleton Electric Co.
  - c. Killark.
6. Welding receptacles:
  - a. Crouse-Hinds.
  - b. Appleton Electric Co.
7. Tele-power poles:
  - a. Wiremold.
  - b. Walker.
8. Dimmers:
  - a. Lutron.
  - b. General Electric.
  - c. P&S.
9. Plug-in strip:
  - a. Wiremold.
  - b. Walker.

B. Submit requests for substitution in accordance with Specification Section 01630.

## 2.02 MATERIALS

### A. Light Switches for Unclassified Areas:

1. Toggle type, quiet action, specification grade with grounding terminal.
2. Back and side wired.
3. Solid silver cadmium oxide contacts.
4. One-piece switch arm rated 20 A, 120/277 V AC.
5. UL listed.
6. Color: Ivory.
7. Wall plate: Type 304 stainless steel.
8. Type: As indicated on Drawings.

### B. Receptacles for Unclassified Areas:

1. Straight blade, grounding type, specification grade.

2. Back and side wired with wrap-around bridge.
  3. Rated 20 A, 125 V AC.
  4. UL listed.
  5. Color:
    - a. For use on normal power: Ivory.
    - b. For use on UPS systems: Red.
    - c. For use on isolated ground systems: Orange.
  6. Wall plate: Type 304 stainless steel.
  7. Type: As indicated on Drawings.
- C. Light Switches for Wet Areas:
1. Pressswitch type, quiet action, specification grade, with grounding terminal.
  2. Back and side wired.
  3. Solid silver cadmium oxide contacts.
  4. One-piece switch arm rated 20 A, 120/277 V AC.
  5. UL listed.
  6. Color: Ivory.
  7. Wall plate: Gray weatherproof pressswitch type.
  8. Type: As indicated on Drawings.
- D. Receptacles for Wet Areas:
1. Straight blade, grounding type, specification grade.
  2. Back and side wired with wrap around bridge.
  3. Rated 20 A, 125 V AC.
  4. UL listed.
  5. Color: Ivory.
  6. Wall plate: Weatherproof, cast aluminum, UL listed, WDL open and closed.
  7. Type: As indicated on Drawings.
- E. Ground Fault Circuit Interrupter Receptacles:
1. Straight blade, grounding type, specification grade.
  2. Rated 20 A, 125 V AC.
  3. UL listed.
  4. Test and reset buttons.
  5. Wall plate: Indoor or weatherproof as required.
  6. Feed-through type.
- F. Light Switches for Corrosive Areas:
1. Corrosion-resistant NEMA 4X enclosure with switch consisting of:
    - a. Fiberglass reinforced polyester enclosure.
    - b. Fiberglass reinforced polyester gasketed wall plate with built-in toggle lever switch with stainless steel shaft.
    - c. Grounding bushing.
    - d. Rated 20 A, 125 V AC.
    - e. UL listed.
    - f. Type: As indicated on Drawings.
    - g. Color: Yellow.

2. Optional: Corrosion-resistant enclosure and switch consisting of:
  - a. Cast copper-free aluminum "FS" or "FD" ridge type hub box.
  - b. Toggle type, quiet action, specification grade with grounding terminal.
  - c. Rated 20 A, 125 V AC with solid silver cadmium oxide contacts.
  - d. UL listed.
  - e. Neoprene gasket.
  - f. Cast aluminum cover with stainless steel screws and lever to activate switch.
  - g. Type: As indicated on Drawings.
  - h. Color: Yellow.
  
- G. Receptacles for Corrosive Areas:
  1. Corrosion-resistant straight blade, grounding type, specification grade.
  2. Back and side wired with wrap-around bridge.
  3. Rated 20 A, 125 V AC.
  4. UL listed.
  5. Color: Yellow.
  6. Box: "FS" or "FD" ridge type cast hub box of copper-free aluminum.
  7. Gasket: Neoprene.
  8. Wall plate: Weatherproof, cast aluminum, UL listed, WDL open or closed.
  9. Type: As indicated on Drawings.
  
- H. Explosion proof Light Switches for Use in Hazardous Areas:
  1. Explosion proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2 areas, Groups E, F, and G.
  2. EDS factory sealed.
  3. Malleable iron body and cover.
  4. Aluminum sealing chamber.
  5. Front operated handle with stainless steel shaft.
  6. Rated 20 A, 125 V AC.
  7. With grounding screw.
  8. Type: As indicated on Drawings.
  
- I. Explosion proof Receptacles for Use in Hazardous Areas:
  1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2, Groups F and G.
  2. Factory-sealed malleable iron receptacle with spring-loaded cover.
  3. Malleable iron mounting box.
  4. Rated 20 A, 125 V AC.
  5. "Dead-front" construction requiring plug to be inserted and rotated to activate receptacle.
  6. Type: As indicated on Drawings.
  
- J. Welding Receptacles:
  1. 60 A, 480 V, 3 pole, 4 wire, grounding type.
  
- K. Plug-In Strip: Surface steel raceway plug-in strip with single 15 A, 125 V, 3 wire grounding-type receptacles spaced 18 IN on center.

1. Prewired with two #12 TW and one #12 TW green insulated ground.
2. Minimum 1-1/4 IN wide x 3/4 IN deep.
3. Suitable fittings and snap-in cover.
4. Finish:
  - a. Stainless steel.
5. Receptacle color:
  - a. For use on normal power: Ivory.
  - b. For use on UPS systems: Red.
  - c. For use on isolated ground systems: Orange.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Mount devices where indicated on the Drawings and as scheduled in Section 16010.
- B. Surface mount receptacles and light switches in concrete construction.
- C. In masonry and metal stud construction, recess mount receptacles and light switches unless device precludes recessed mounting or unless otherwise noted on the Drawings.
- D. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.
- E. Set switches and receptacles plumb and vertical to the floor.
- F. Set recess-mounted switches and receptacles flush with face of walls.
- G. Do not connect dimmers to loads in excess of 80 percent of the rating of the dimmer.
- H. Provide blank plates for empty outlets.

End Of Section



## SECTION 16143

### TERMINAL BLOCKS

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This section covers terminal blocks for control and other wiring.

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

##### 1.03 MANUFACTURERS

- A. Terminal blocks shall be Allen Bradley, Entrelec, Phoenix Contact, Allen-Bradley, or equal.
- B. Surge protection blocks shall be MTL, Phoenix Contact, Termatrab, or equal.
- C. Power distribution blocks shall be Gould, Allen-Bradley Corporation, or equal.

#### PART 2 - PRODUCTS

##### 2.01 TERMINAL BLOCKS

- A. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.
- B. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
- C. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.
- D. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and

rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.

- E. DIN rail shall be prepunched, zinc bichromate plated steel. Symmetrical DIN rail shall be 35mmX7.5mm, minimum.
- F. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.

## 2.02 SURGE PROTECTION BLOCKS (SPB)

- A. Analog inputs and outputs shall be terminated at surge protection blocks (SPB). The SPBs shall be designed for a working voltage of 32 volts, and shall be fused.
- B. SPBs shall provide full hybrid line to line protection, and shall have a GDT rating of 10,000 A (8/20 $\mu$ s pulse waveform).
- C. SPBs shall be UL94 V-2 listed.

## 2.03 POWER DISTRIBUTION BLOCKS (PDB)

- A. PDBs shall be Electro-tin plated and manufactured from high strength 6061-T6 aluminum alloy.
- B. PDBs shall be UL Recognized rated 90° C and CSA Certified.
- C. PDBs shall provide flexibility in using the connector as an in line splice or to reduce conductor size.
- D. PDBs shall be rated for 600 Volts and dual rated for Copper and Aluminum Conductor.
- E. PDBs shall have the sizes and ratings as shown on the Drawings.

# PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. Each terminal block and fuse holder shall be identified with the circuit number, or conductor number, corresponding to the identification appearing on the shop Drawings for the equipment, or system.
- B. Terminal block and fuse holder markers shall be computer printed plastic-type, with permanent markings.
- C. End clamps and end sections shall be installed on each terminal block and fuse holder assembly.

D. Terminal blocks for DC voltages shall be blue, and AC voltages shall be gray.

End of Section

## SECTION 16160

### ENCLOSURES

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This specification includes enclosures to house electrical controls, instruments, terminal blocks, and serve as junction boxes where shown on the Drawings.

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

##### 1.03 MANUFACTURERS

- A. Enclosures shall be manufactured by Hammond, Hoffman, Rittal, or equal.

#### PART 2 - PRODUCTS

##### 2.01 STEEL

- A. Enclosures shall be fabricated from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.
- B. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket. All wires entering or leaving the enclosure shall terminate on terminal strips. All wires and terminals shall be clearly identified as specified elsewhere in these specifications.
- C. Finish shall be white enamel interior, light gray enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Drawings should be checked for special conditions.

##### 2.02 NEMA RATING

- A. Unless otherwise indicated on the Drawings, enclosures shall be NEMA 12 for indoors, NEMA 4X for corrosive areas, and NEMA 4 for outdoor installations. NEMA 4X enclosures shall be stainless steel, unless noted otherwise. NEMA 4 enclosures shall also be used in wet, or wash down areas.

2.03 FIBERGLASS

- A. Enclosures shall be heavy-duty, compression molded, fiberglass reinforced polyester, high impact, heat resistant, NEMA 4X.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Enclosures shall be installed as indicated on the Drawings, and according to manufacturer's instructions.
- B. Enclosures shall be properly grounded, and shall include ground straps connected to hinged doors and accessories.

End of Section

## SECTION 16161

### CONTROL PANELS

#### PART 1 - GENERAL

##### 1.01 SUMMARY

- A. Section Includes:
  - 1. Control panels.
  - 2. Products shall be submitted for review in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

##### 1.02 QUALITY ASSURANCE

- A. Referenced Standards:
  - 1. American Society for Testing and Materials (ASTM):
    - a. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
  - 2. Joint Industrial Council (JIC):
    - a. EMP-1, Mass Production Equipment.
  - 3. National Electrical Manufacturers Association (NEMA):
    - a. ICS 4, Terminal Blocks for Industrial Use.
    - b. ICS 6, Enclosures for Industrial Controls and Systems.
    - c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
  - 4. National Fire Protection Association (NFPA):
    - a. National Electric Code (NEC).
  - 5. Underwriters Laboratory (UL)
    - a. UL 508A, Standard for Industrial Control Panels
- B. Miscellaneous:
  - 1. Prior to placement of conduit feeds, assure approved control panel layouts available.
  - 2. Assure completely matching color tones for any individual color specified.
  - 3. Provide panel with the required NEMA rating per NEMA Publication No. 250 to meet classifications shown on drawings or specifications.

##### 1.03 SUBMITTALS

- A. Shop Drawings:
  - 1. Scaled panel face and subpanel face instrument and nameplate layout drawings.
  - 2. Panel and subpanel materials of construction.
  - 3. Panel and subpanel dimensions and weights.
  - 4. Panel access openings.
  - 5. Conduit and wiring access locations.
  - 6. Internal wiring and terminal block drawings.

7. Nameplate text.
8. Scaled layouts of any graphic panels.

B. Operation and Maintenance Manuals.

## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
  1. Enclosures:
    - a. Hoffman
    - b. Rittal
    - c. Hammond
    - d. Or equal.
- B. Submit requests for substitution in accordance with the Contract Documents.

### 2.02 MATERIALS

- A. Front Panel, Subpanel or Front Door: Steel.
- B. Frame and Bottom Angles: Steel.
- C. Top, Sides, Back, Sides, and Back Door: Steel.
- D. Hinges: Stainless steel.
- E. Nameplates: Phenolic.
- F. Filler Panels: Steel.

### 2.03 ACCESSORIES

- A. Control Panels:
  1. Single function pilot lights.
    - a. Flush, non-protruding.
    - b. Heavy-duty lights with glass lenses.
    - c. Colors:
      - 1) Red: "ON" or "RUNNING."
      - 2) Blue: "REQUIRED" or "STAND-BY."
      - 3) Amber: "Alarm."
      - 4) Green: "OFF" or "STOPPED."
    - d. Lens-type with LED illumination.
- B. Panel Nameplates and Identification:

1. Identify each item on the control panel with rectangular nameplates.
2. Provide nameplates with black letters on white background.
3. Minimum letter height is 1/2 IN for instrument description and 1/4 IN height for instrument tag number.
4. For all panels which have a panel identification number, provide 2 IN high white nameplate with black, 1 IN high lettering with panel identification number.

## 2.04 FABRICATION

### A. General:

1. Fabricate panels with instrument arrangements as shown on the Drawings.
2. Prime control panels with rust inhibitive shop applied primer and paint with two coats of UV resistant white water-based paint.
3. Finish interior of panel with epoxy glass white.
4. Provide control panel which meets the following requirements:
  - a. Panel depth per JIC EMP-1-1967, E7.1.4.
  - b. Door opening per JIC EMP-1-1967, E7.1.5.
  - c. Data pocket per JIC EMP-1-1967, E7.1.6.
  - d. Rigidity per JIC EMP-1-1967, E7.1.7.
  - e. Door alignment and reinforcement per JIC EMP-1-1967, E7.1.8.
  - f. Panel holes and openings per JIC EMP-1-1967, E7.3.2, E7.3.3, and E7.3.4.
  - g. Doors per JIC EMP-1-1967, E7.5.
  - h. Clear panel mounting space per JIC EMP-1-1967, E8.2.9.
  - i. Panel mounted control device location per JIC EMP-1-1967, E8.3.4.
  - j. Clearances in enclosures per JIC EMP-1-1967, E8.4.

### B. Free-Standing Panels:

1. Minimum construction thicknesses:
  - a. Front panel, subpanel, or front door with cutouts: 0.123 IN.
  - b. Top, sides, back, filler plates and side or doors with no cutouts: Minimum thickness per, NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Completely enclosed, self-supporting, and gasketed dusttight.
4. Edges turned back minimum of 2 IN.
5. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
6. Arrange control panel faces continuous and flush with face of adjacent electrical motor control centers.
7. Provide filler panels where necessary to close gaps between panels or back of panel and wall. Provide full length flush pan doors.
8. Provide full length piano hinges rated for 1.5 times door plus instrument weight.
9. Furnish doors with keyed alike locking handles and three point catch.
10. Provide appropriate conduit, wiring, and instrument openings in accordance with best panel design.
11. After cutouts have been made, finish opening edges to smooth and true surface condition.



12. Provide each panel with lifting eyebolts. Furnish hot-dipped galvanized steel base channels.
13. Slotted bolt holes in base, 1 1/2 long for field adjustment.

C. Wall Mounted Panels:

1. Minimum construction thicknesses:
  - a. Front panel, subpanel or door with cutouts:
    - 1) Width or height not exceeding 42 IN: 0.093 IN.
    - 2) Width or height exceeding 42 IN: 0.123 IN.
  - b. Side, top, back and doors without cutouts: minimum thickness per NEMA ICS 6, Tables 3-8,9.
2. Seams continuously welded and ground smooth.
3. Body stiffeners for extra rigidity if either height or width exceeds 28 IN.
4. Rolled lip around all sides of enclosure door opening.
5. Gasketed dust tight.
6. Three-point latching mechanism operated by oil tight key-locking handle.
7. Key doors alike.
8. Continuous heavy GA hinge pin on doors.
  - a. Hinges rated for 1.5 times door plus instrument weight.
9. After cutouts have been made, finish opening edges to smooth and true surface condition.
10. Front full opening door.
11. Brackets for wall mounting.

D. Panel Front Construction:

1. Minimum construction thicknesses: per NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Edges turned and ground smooth to touch and visual appearance.
4. At joints where panel face meets side walls, provide dustproof sponge rubber gasket entire height and face.
5. Use full length piano hinges rated for 1.5 times door weight for panel access door.
6. Equip doors with locking devices and handle and three point catches.
7. Finish all instrument cutouts smooth and true.

E. Panel Wiring and Piping:

1. Factory pipe and wire panels to identified terminal blocks equipped with screw type lugs.
2. Install all wiring without splicing in factory in raceways:
  - a. Size raceways per the requirements of NEC Article 312.
  - b. Raceways shall have removable covers.
3. Wire bending space shall be in accordance with Tables 307B, C in NEMA ICS 6.
4. Keep AC power lines separate from low-level DC lines, I/O power supply cables, and all I/O rack interconnect cables.
5. Keep AC signal wires separate from DC signal wires.
6. When I/O wiring must cross AC power wiring, it shall only do so at right angles.

7. Arrange circuits on terminal blocks plus any spare conductors on adjacent terminals.
8. Provide necessary power supplies for control equipment.
9. Equip each panel with a main thermal magnetic circuit breaker. Limit load to maximum of 80 percent of circuit breaker rating.
10. Provide all necessary stabilizing voltage transformers, balancing potentiometers and rectifiers as necessary for specific instrument requirements.
11. Assure each panel mounted device is bonded or otherwise grounded to panel or panel grounding system by means of locknuts or pressure mounting methods.
  - a. Equip panel with grounding terminals.
12. Arrange wiring with sufficient clearance for all leads.
13. Wiring to subpanels or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without disconnecting wiring.
14. Identify all wires with plastic sleeve type wire markers at each end. Markers shall:
  - a. Identify circuit numbers.
  - b. Identify function and polarity.
15. Provide all wiring according to color code as follows:

| COLOR OF INSULATION | 120 V, 60 hZ SERVICE | LOW VOLTAGE DC SERVICE |
|---------------------|----------------------|------------------------|
| Black               | Phase Conductor      |                        |
| Red                 | Signal Wire          |                        |
| White               | Neutral              |                        |
| Brown               |                      | DC Common              |
| Orange              |                      | 24VDC/12VDC Power      |
| Blue                |                      | Signal Wires           |
| Green               | Ground               | Ground                 |

- a. For intrinsically safe instruments, provide uniform and compatible additional color scheme.
16. Termination requirements:
  - a. Terminal block markings, mechanical characteristics and electrical characteristics shall be in accordance with NEMA ICS 4.
  - b. Terminals shall facilitate wire sizes as follows:
    - 1) 120 V AC applications: Wire size 12 AWG and smaller.
    - 2) Other: Wire size 14 AWG and smaller.
  - c. Provide terminal blocks with continuous marking strip.
  - d. Tag each I/O terminal to indicate tag number of the connected device.
  - e. Provide terminals for individual termination of each signal shield.
  - f. Provide 20 percent excess terminals for future expansion.
17. Pneumatic tubes and appurtenances:
  - a. Provide 1/4 IN OD pneumatic control tubing.
  - b. Main headers within panels shall be minimum 1 IN.
  - c. Compression-type pressure fittings.

- d. Equip panel instrument leads with globe type isolation valve.
- e. Connection to devices not in the panel shall be terminated on tubing terminal plate.
- f. Install tubing neatly and mount securely.
- g. Do not route tubing in front of or in wiring raceways.
- h. Code terminal plates.
- i. Supply and install dual function filter regulator to serve pneumatic devices.

F. Panel Lighting and Power:

- 1. Receptacles:
  - a. Panels less than 4 FT long:
    - 1) One electrical outlet.
    - 2) One incandescent light fixture with switch(es) and separate circuit breakers.
  - b. Panels or panel faces greater than 4 FT long:
    - 1) One electrical outlet per 6 FT of length.
    - 2) Continuous fluorescent lighting strip with switches and separate circuit breakers.

G. Environmental Controls:

- 1. Furnish circulation fans near hot spots where required to prevent temperature from exceeding instrument rating.
- 2. Over-temperature switches shall be utilized to provide special cooling if required to maintain operating temperatures within the manufacturer's specified range.
- 3. Air conditioning applications shall include means of preventing moisture condensation.
- 4. For panels or control cabinets located outside, or in area classification requiring a NEMA 4 or 4X rating:
  - a. Provide printed circuit boards with "Humiseal" conformal coating, covering entire components on both side of board except not covering adjustable components.
  - b. Furnish gold plated edge connectors on circuit board and socket contacts.
  - c. Install thermostatically controlled condensation protection heaters or 10 CU IN desiccant packs in enclosures housing electronic equipment.
    - 1) Provide one pack for each 10 CU FT of panel capacity.

## 2.05 MAINTENANCE MATERIALS

A. Extra Materials:

- 1. Replacement Bulbs. Provide minimum 25 percent or 25 bulbs, whichever is greater, for replacement indicating light bulbs for each type of indicator furnished in this Project.

## PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install free-standing panels on concrete pads as detailed on the Drawings.
- B. Anchor panel fronts rigidly into wall system with approved anchorage devices.

End of Section

## SECTION 16170

### GROUNDING

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. A ground grid system consisting of the indicated configuration of copper wires, and ground rods, or concrete encased grounding electrodes ("UFERs") shall be provided to minimize station potential gradient irregularities and drain leakage and fault currents to earth.
- B. Whether indicated on the Drawings or not, neutral conductors, cable shields, metallic conduits, cable terminations, junction boxes, poles, surge arresters, and other noncurrent-carrying metallic parts of equipment shall be grounded.

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

##### 1.03 REFERENCES

- A. National Electrical Code (NEC) Article 250.

#### PART 2 - PRODUCTS

##### 2.01 GENERAL REQUIREMENTS

- A. A resistance of not greater than 25 ohms shall be provided, unless otherwise specified. Ground resistances shall be measured as herein described. Resistances of systems requiring separate ground rods, rather than a counterpoise, shall be measured separately before bonding below grade. The combined ground resistance of separate systems bonded together below grade may be used to meet the specified ground resistance, but the minimum number of rods indicated must still be provided.

##### 2.02 GROUND RODS

- A. Ground rods shall be copper-clad steel conforming to UL 467, 3/4 inch in diameter by 10 feet in length. Unless otherwise indicated, ground rods shall be driven into the ground until tops of rods are approximately 6 inches below finished grade. In counterpoise systems, tops of ground rods shall be approximately at elevations of counterpoises. Where the specified ground resistance cannot be met with the indicated number of ground rods, additional ground rods, longer ground rods, or deep-driven sectional rods shall be installed and connected until the specified resistance is obtained, except that not

more than three additional ground rods shall be required at any one installation. Ground rods shall be spaced as evenly as possible at least 6 feet apart and connected below grade.

## 2.03 CONNECTIONS

- A. Connections above grade shall be made with bolted solderless connectors, and those below grade shall be made by a fusion-welding process. In lieu of a fusion-welding process, a compression ground grid connector of a type which uses a hydraulic compression tool to provide the correct circumferential pressure may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

## 2.04 GROUNDING ELECTRODE CONDUCTOR

- A. Service entrance ground wires shall be sized in accordance with NEC Table 250.66, unless otherwise indicated on the Drawings. After being located to provide maximum physical protection, exposed ground wires shall be securely attached to structural supports at not more than 2-foot intervals with suitable fasteners. Bends greater than 45 degrees in ground wires are not permitted. Routing of ground conductors through concrete should be avoided, except where specifically called for in these Documents. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit, so as to provide an opening for the ground wire. The opening shall be sealed with a suitable compound after installation of the ground wire.

## 2.05 EQUIPMENT GROUNDING CONDUCTOR

- A. Neutral conductors shall be grounded where indicated. Equipment grounding conductors shall be sized in accordance with NEC Table 250.122, unless otherwise indicated. Ground wires shall be protected by conduit, where such wires run exposed above grade in nonfence-enclosed areas, or are run through concrete construction. Where concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit, so as to provide an opening for the ground wire. The opening shall be sealed with a suitable compound after installation of the ground wire. Bends greater than 45 degrees in ground wire connections to the ground rods, or counterpoises are not permitted.

## 2.06 EQUIPMENT GROUNDING

- A. Equipment frames of motor housings, metallic tanks, metallic equipment enclosures, metal splicing boxes, chain-link fencing, and other metallic noncurrent-carrying metal items, shall be grounded. Connections to earth shall be made in the same manner as required for system grounding. Equipment or devices operating at less than 750 volts may be connected to secondary neutral grounding electrodes.

## 2.07 SURGE ARRESTER GROUNDING

- A. Surge arresters shall be grounded. Resistance to ground for intermediate-class arresters shall be not more than 10 ohms and for distribution-class arresters shall be not more than 25 ohms. Ground wire connections shall be not less than No. 4 AWG for distribution arresters and No. 1/0 AWG for intermediate arresters. Connections to earth shall be made in the same manner as required for neutral conductors. Surge arrester grounds may use the same ground wires provided for equipment operating at more than 750 volts. Surge arrester and secondary neutral grounds shall be separate from and independent of each other but both grounds shall be bonded together below grade at the ground rods or may utilize a common counterpoise.

## 2.08 LIGHTING POLE GROUNDING

- A. Base of lighting poles shall be connected to an adjacent ground rod as indicated on Drawings. A ground connection from poles back to neutral ground points shall also be provided utilizing equipment grounding conductor.

## 2.09 METALLIC STRUCTURES

- A. Metallic structures and buildings shall be grounded per NEC.

## 2.10 GROUNDING RINGS

- A. When required, grounding rings shall be installed using bare copper cable with ground rods at least 25 feet intervals using thermoweld connecting means as indicated on Drawings in accordance with NEC requirements.

# PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. It is the intent of these Contract Documents that all device and equipment grounds shall be run as a separate conductor in the conduit from the equipment to the distribution panels or system ground. Wireways and enclosures shall be properly bonded and grounded, and ground conductors shall be run for all circuits.
- B. Equipment cases and devices shall be grounded. Ground rods shall be driven, and concrete encased conduits installed, before a building, or structure is built, and ground conductors brought through the concrete to accessible points for grounding equipment. These systems shall be installed at each structure, where transformers, switchboards, panelboards, and MCCs are installed.
- C. Duct banks shall contain a concrete encased system bare copper ground conductor. The system ground conductors shall run continuously in duct banks, through handholes and other raceway boxes. The system ground shall be connected to the structure grounding systems to provide a continuous grounding system. Each metallic raceway, panel,

switchboard, and other metallic devices associated with the electrical and control systems shall be bonded to this grounding system.

- D. Ground rod shall be installed not less than 6 inches below grade. Equipment, neutral, and surge arrester ground wires shall be connected to the ground grid as indicated.

### 3.02 TESTS

- A. Test the grounding and bonding system in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. No part of the electrical system shall be energized until all station grounding system components have been tested and demonstrated to comply with the requirements specified, and until associated test reports have been submitted and approved.

### 3.03 TEST RESULTS

- A. Perform the above tests and submit a certified test report prior to energizing the equipment.

End Of Section



## SECTION 16190

### SUPPORTING DEVICES

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. Supports, anchors, sleeves, and seals, are indicated on the Drawings, schedules, and specified in other sections of these Specifications.
- B. Types of supports, anchors, sleeves and seals specified in this section include the following:
  - 1. One-hole Conduit Straps
  - 2. One-Hole Conduit Straps with Clamp Backs
  - 3. Two-Hole Conduit Straps
  - 4. Conduit Hangers
  - 5. I-beam Clamps
  - 6. Channel Clamps
  - 7. Round Steel Rods
  - 8. Drop-in Anchors
  - 9. Wedge Type Anchor Bolts
  - 10. Lead Expansion Anchors
  - 11. Toggle Bolts
  - 12. Wall and Floor Seals
  - 13. Cable Supports
  - 14. U-Channel Strut System
  - 15. Sleeves

##### 1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

#### PART 2 - PRODUCTS

##### 2.01 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following: Abbeon Cal Inc., Ackerman Johnson Fastening Systems Inc., Elcen Metal Products Co., Ideal Industries, Inc., Joslyn Mfg and Supply Co., McGraw Edison Co., Rawlplug Co. Inc., Star Expansion Co., U.S. Expansion Bolt Co., Allied Tube and Conduit Corp., B-Line Systems, Inc., Greenfield Mfg Co., Inc., Midland-Ross Corp., O-Z/Gedney Div; General Signal Corp., Power-Strut Div.; Van Huffer Tube Corp., and Unistrut Div; GTE Products Corp., and Robroy Industries.

## 2.02 GENERAL

- A. Provide supporting devices that comply with manufacturers standard materials, design, and construction, in accordance with published product information, and as required for complete installations, and as specified herein.

## 2.03 SUPPORTS

- A. Provide supporting devices of types, sizes, and materials indicated, and having the following construction features:
  - 1. One-Hole Conduit Straps: For supporting electrical metallic tubing, and liquidtight flexible conduit; zinc plated steel, stainless steel or galvanized steel; snap-on, heavy duty.
  - 2. One-Hole Conduit Straps with Clamp Backs: For supporting rigid metal conduit, and intermediate metal conduit; cast galvanized steel.
  - 3. Two-Hole Conduit Straps: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
  - 4. Conduit Hangers: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
  - 5. I-Beam Clamps: Electroplated zinc or hot dipped galvanized malleable iron.
  - 6. Channel Clamps: Electroplated zinc or hot dipped galvanized steel.
  - 7. Round Steel Rod: National coarse thread, electroplated.

## 2.04 ANCHORS

- A. Provide anchors of types, sizes, and materials indicated, with the following construction features:
  - 1. Lead Expansion Anchors: For CMU walls, 1/4"-20 threads, set tool required.
  - 2. Toggle Bolts: Electroplated steel, size as required.
  - 3. Drop-in Anchors: Stainless steel, size as required.
  - 4. Anchor Bolts: Stainless steel, size as required.
  - 5. Half-round head, non-removable anchor bolts shall not be used.

## 2.05 SEALS

- A. Provide seals of types, sizes and materials indicated; with the following construction features:
  - 1. Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sized indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.
  - 2. Conduit sealing bushings shall be manufactured by O-Z/Gedney, Model CSMI, or equal.
  - 3. The conductor sealing bushings shall be manufactured by O-Z/Gedney, Model CSBG, or equal.

2.06 CONDUIT CABLE SUPPORTS

- A. Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers; construct 2" rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable-iron casting with hot-dip galvanized finish.

2.07 U-CHANNEL STRUT SYSTEM

- A. Provide U-channel strut system for supporting electrical equipment, 12-gage hot-dip galvanized steel, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with the following fittings that mate and match with U-Channel:
  - 1. Fixture hangers
  - 2. Channel hangers
  - 3. End caps
  - 4. Beam clamps
  - 5. Wiring stud
  - 6. Thinwall conduit clamps
  - 7. Rigid conduit clamps
  - 8. Post Bases
  - 9. U-bolts

2.08 PIPE SLEEVES

- A. Provide pipe sleeves from the following:
  - 1. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

2.09 PVC COATED U-CHANNEL STRUT SYSTEM

- A. Provide PVC Coated U-channel strut system for supporting electrical equipment, 20 mil PVC coated steel, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with all Stainless Steel hardware, and the following fittings that mate and match with PVC Coated U-Channel:
  - 1. PVC Coated Strut nut
  - 2. PVC Coated Pipe straps
  - 3. Touch up compound (Gray)

2.10 STAINLESS STEEL U-CHANNEL STRUT SYSTEM

- A. Provide Stainless Steel U-channel strut system for supporting electrical equipment, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with all stainless steel hardware, and the following stainless steel fittings that mate and match with Stainless Steel U-Channel:
  - 1. Fixture hangers
  - 2. Channel hangers
  - 3. End caps
  - 4. Beam clamps
  - 5. Wiring stud

6. Post bases
7. Rigid conduit clamps
8. U-bolts

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.
- B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of 2 or more parallel runs of conduits to be supported together on channel type hangers where possible. Install supports with spacing indicated and in compliance with NEC requirements.
- D. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.
- E. Comply with manufacturer's recommendations for touch up of field cut ends or damaged PVC coated U-channel and fittings.
- F. Remove burrs and apply a cold zinc galvanizing paint to field cut galvanized U-channel strut.

End of Section

## SECTION 16195

### ELECTRICAL IDENTIFICATION

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. Electrical identification work specified in this section covers the following:
  - 1. Buried cable warnings
  - 2. Electrical power, control and communication conductors
  - 3. Operational instructions and warnings
  - 4. Danger signs
  - 5. Equipment/system identification signs

##### 1.02 SUBMITTALS

- A. Submittals to the engineer shall include the following:
  - 1. Manufacturers data on electrical identification materials and products
  - 2. Samples of each color, lettering style and other graphic representation required for each identification material or system

##### 1.03 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering electrical identification products maybe incorporated in the work include, but not limited to, the following:
  - 1. Brady, W.H. Co.
  - 2. Ideal Industries, Inc.
  - 3. Panduit Corp.
  - 4. or, equal

##### 1.04 QUALITY COMPLIANCE

- A. Comply with applicable requirements of UL Std. 969, "Marking and Labeling Systems", pertaining to electrical identification systems.
- B. Comply with applicable requirements of NEMA Std. No's WC-1 and WC-2 pertaining to identification of power and control conductors.

#### PART 2 - PRODUCTS

##### 2.01 GENERAL

- A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an

application, selection is Installer's option, but provide single selection for each application.

## 2.02 COLOR-CODED CONDUIT MARKERS

- A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360 degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering that indicates voltage of conductor(s) in conduit. Provide 8" minimum length for 2" and smaller conduit, 12" length for larger conduit.
- B. Unless otherwise indicated or required by governing regulations, provide white markers with black letters.

## 2.03 CABLE AND CONDUCTOR WIRE MARKERS

- A. Cable and conductor wire markers shall be self laminating vinyl on white background, printed using a Brady TLS2200 printer, Seton printer, or equal. Handwritten wire markers are not acceptable.

## 2.04 SELF-ADHESIVE PLASTIC SIGNS

- A. Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., 208V, EXHAUST FAN, RECTIFIER.
- B. Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.

## 2.05 LETTERING AND GRAPHICS

- A. Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

# PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. Install electrical identification products as indicated, in accordance with manufacturer's written instructions, and requirements of NEC.

- B. Where identification is to be applied to surfaces that require finish, install identification after completion of painting.
- C. Comply with governing regulations and requests of governing authorities for identification of electrical work.

### 3.02 CONDUIT IDENTIFICATION

- A. Where electrical conduit is exposed in spaces with exposed mechanical piping that is identified by a color-coded method, apply color-coded identification on electrical conduit in manner similar to piping identification. Except as otherwise indicated, use white as coded color for conduit.

### 3.03 CABLE/CONDUCTOR IDENTIFICATION

- A. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

### 3.04 EQUIPMENT/SYSTEM IDENTIFICATION

- A. Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication-control-signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
  - 1. Panelboards, electrical cabinets and enclosures.
  - 2. Access panel/doors to electrical facilities.
  - 3. Major electrical switchgear.
- B. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with brass or stainless steel screws, except use adhesive where screws should not or cannot penetrate the substrate.

### 3.05 CIRCUIT IDENTIFICATION

- A. The 3-phase wires shall be identified at the switchgear, panelboards and motor control centers as Phases A, B, and C. At 277/480V, Phase A shall be brown, Phase B shall be orange, and Phase C shall be yellow. The neutral shall be gray or white.



- B. In addition to color coding all conductors, each conductor shall be identified in each pull box, manhole, panelboard, cable tray, or termination with circuit identification markers. This identification is applicable to all power, control, alarm, and instrumentation conductors and these markings shall be recorded on the Record Documents. Markers shall be slip-on PVC sleeve type as manufactured by Brady, Seton, or equal.
- C. Markers for other cabling shall be B-292 vinyl as manufactured by Brady, Seton, or equal.
- D. Exposed medium voltage conduits shall be labeled at 50-foot intervals with 1-inch letters stating the voltage - example - "12,470 volts". Labels shall be vinyl plastic as manufactured by Brady, Seton, or equal.

### 3.06 AUTOMATIC EQUIPMENT WARNING SIGNS

- A. Permanent warning signs shall be mounted at all mechanical equipment that may be started automatically or from remote locations. Signs shall be in accordance with OSHA regulations and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the Engineer.
- B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

CAUTION  
THIS EQUIPMENT STARTS  
AUTOMATICALLY  
BY REMOTE CONTROL

### 3.07 HIGH VOLTAGE WARNING SIGNS

- A. Permanent and conspicuous warning signs shall be mounted on all equipment, doorways to equipment rooms, pull boxes, manholes, where the voltage exceeds 600 volts.
- B. Signs shall be in accordance with OSHA regulation, and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the Engineer.
- C. Signs shall be 7 inches high by 10 inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

WARNING  
HIGH VOLTAGE  
KEEP OUT



3.08 CONDUCTOR FASTENERS

- A. Glue-on type conductor fasteners shall not be used in any panels, panelboards, switchboards, switchgear, motor control centers, or other enclosures containing electrical devices and/or conductors.

End of Section

## SECTION 16305

### 5KV CLASS CABLE

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This specification covers single conductor 5,000 volt shielded copper power cable insulated with an ozone and discharge resistance flexible, rubber-like thermosetting dielectric for medium voltage applications which shall be suitable for use in wet and dry locations in conduit, cable tray, underground ducts, direct burial and aerial installations.

##### 1.02 SUBMITTALS

- A. Products shall be submitted to the Engineer for review in accordance with Section 01600 of the Specifications and other Contract Documents.
- B. Product technical data including:
  - 1. Acknowledgment that products submitted meet requirements of standards referenced.
  - 2. Manufacturer's installation instructions.
  - 3. Complete catalog data showing compliance with complete Specifications.
- C. Test reports:
  - 1. The switchgear terminations manufacturer shall, upon request, furnish test reports which verify device stability with time, temperature, and stress variations.
  - 2. Motor connection kits:
    - a. Meet or exceed the AC withstand and impulse requirements of IEEE 404 stand for power cable splices. Manufacturer shall provide test reports demonstrating compliance with this standard.
  - 3. When assembled on cables, the splice shall be capable of passing the electrical test requirements of IEEE 48, IEEE 404, and water immersion tests of IEEE 386. Splice manufacturer shall provide a test report demonstrating compliance with the above test requirements.
- D. Licenses And Training
  - 1. High Voltage Construction License (A-17).
  - 2. Certificates of training for their installers.
- E. Drawings showing exact cable routing.

##### 1.03 QUALITY ASSURANCE

- A. Association of Edison Illuminating Engineers (AEIC).

- B. Insulated Cable Engineers Association (ICEA) and National Electrical Manufacturers Association (NEMA):
  - 1. S-68-516/WC 8 Ethylene-Propylene Rubber - insulated wire and cable for transmission and distribution of electrical energy.
- C. Institute of Electrical and Electronics Engineers:
  - 1. IEEE - 48: Standard test procedures and requirements for high-voltage alternating-current table.
  - 2. IEEE - 400: Guide for making high-direct-voltage tests on power cable systems in the field.
  - 3. IEEE - 386: Standard for separable insulated connector systems for power distribution systems above 600 V.
  - 4. IEEE - 404: Standard for cable joints for use with extruded dielectric cable rated 5000 V through 46,000 V and cable joints for use with laminated dielectric cable rated 2500 V through 500,000 V.
- D. National Electrical Code (NEC)
- E. Underwriters' Laboratories (U.L.)
  - 1. UL 1072, Standard for Safety Medium-Voltage power cables.

## PART 2 - PRODUCT

### 2.01 5KV CLASS CABLE

- A. The cables shall be single-conductors for 90 degrees C continuous normal operation. They shall be constructed as follows: Conductor shall be stranded, Class B, annealed copper, covered with an extruded semi-conducting EPR strand screen, 140-mil ethylene propylene insulation, extruded EPR semi-conducting insulating screen, 5-mil bare copper shielding tape with 12½ percent minimum overlap, 60-mil overall flame retardant PVC or chloro-sulfonated polyethylene jacket (80-mil for 1/0 size or larger). They shall be rated 5 kV, type MV-105, with 133 percent insulation level. Conductor screen, insulation and insulation screen shall be extruded simultaneously. The insulation shall be distinctively different color from the insulation screen.
- B. Cables shall be manufactured as per the applicable ICEA S68-516 and AEIC CS-86 standards. When in conflict, the more stringent test shall apply. The completed cables shall be tested for corona discharge per AEIC requirements. A copy of the original X-Y plot showing discharge levels shall be submitted with the certified test reports.
- C. The pulling tension and side-wall pressures, as recommended by the cable manufacturer, shall not be exceeded. Pull boxes located as indicated on the Drawings are based on nominal pulling tension and side-wall pressures. Additional pull boxes shall be installed, as required, to meet the cable manufacturer's recommendations.

- D. The EP insulation must contain no polyethylene polymer as a component. The ethylene content of any of the EP rubbers used in the insulation must not exceed 72% by weight ethylene. Both features to limit the degree of susceptibility of "treeing" experienced by highly crystalline materials.
- E. The cable manufacturer shall have a minimum of 15 years proven and successful experience with the manufacturing of EPR insulated cables at the facility from which the cable will be made.
- F. Each reel of cable furnished shall be newly manufactured, (no more than 12 months old), and shall bear a tag containing name of manufacturer, NEC designation and year of manufacture.
- G. Other parts of the cable system such as joints and terminations shall have ratings not less than the rating of the cables on which they are installed. Separable insulated connectors shall have nominal voltage ratings coordinated to associated apparatus ratings rather than cable ratings when used to connect cable to apparatus.
- H. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of performed joints. Shields shall be grounded at each joint. Separable insulated connectors of suitable construction or standard splice kits shall be used. Splice kits may be of the heat-shrinkable type for the rated voltage. Cable joints shall provide insulation and jacket equivalent to that of the associated cable.
- I. Five kV cable shall be manufactured by Okonite, or equal.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install cables in reinforced concrete underground chases or ducts as indicated on the Drawings.
- B. Coordinate work with other trades in order to avoid complications and interference.
- C. Installation shall be such to readily provide for future expansions.
- D. The cables shall be installed as per manufacturers recommendation with appropriate equipment. Cables shall not be pulled with a truck, automobile, or similar equipment which may exceed the manufacturer's recommended cable specifications. The Contractor shall replace the cables at no cost to owner if such happens.
- E. The installing Contractor must be licensed for High Voltage Construction (A-17).

3.02 5KV CABLE TESTS

- A. Test cables in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. All reels of new cable shall be given a post delivery hi-potential DC insulation test in accordance with NETA-ATS 2003 to prove the cables are acceptable prior to installation. Cable shall be installed on reels such that both ends are exposed and available for testing. Replace any cable failing the test.

3.03 SWITCHGEAR TERMINATIONS (5 KV CLASS CABLE)

- A. Terminations shall be stress cones type. Termination kits supplied shall be capable of properly terminating single conductor polymeric-insulated cable. Kits shall meet Class I requirements and be design proof tested per IEEE 48-1975 and be capable of passing a test sequence per draft and revisions of IEEE 404-1986. Kits as specified shall accommodate any common form of cable shielding/construction without the need for special adapters and accessories, and shall accommodate a wide range of cable sizes and, also, be capable of being properly installed on out-of-round or out-of-tolerance cable as per relevant ICEA standards. Kits shall accommodate commercially available connectors.
- B. Terminations for single conductor cables shall consist of heat shrinkable stress control and outer nontracking insulation tubings along with a high relative permittivity stress relief mastic for insulation shield cutback treatment with a heat activated sealant for environmental sealing. Three conductor kits shall contain necessary materials to seal the cable jacket, phase conductors, and any ground wires, as well as re-jacket phase and ground conductors.
- C. The manufacture shall, upon request, be able to demonstrate fifteen years of actual field experience and suitable accelerated and real-time testing of weather resistance. Test reports shall also be available, upon request, which verify device stability with time, temperature, and stress variations.
- D. Termination kits shall be manufactured by Raychem Corporation, or equal.

3.04 MOTOR TERMINATIONS (5 KV CLASS CABLE)

- A. All feeder cable connections to unshielded motor leads shall be insulated and sealed with factory engineered kits. Motor connection kits shall consist of heat-shrinkable, corona resistant, polymeric insulating materials and a high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Bolt connection area shall be kept free of mastics and fillers to facilitate rapid stripping and re-entry.
- B. Motor connection kits shall accommodate a range of cable sizes for both inline and stub type configurations. All connection kits shall be independent of cable manufacturer's tolerances.

- C. Motor connection kits shall meet or exceed the AC withstand and impulse requirements of IEEE 404-1986 standard for power cable splices. Manufacturer shall provide test reports demonstrating compliance with this standard.
- D. Motor connection kits shall be manufactured by Raychem Corporation, or equal.

### 3.05 SPLICES (5 KV CLASS CABLE)

- A. In general, cables shall be run without splices between termination to equipment. Splices shall be made only when authorized by the Engineer and only where cables have to be cut to meet manufacturer's pulling tension requirements.
- B. Power cable splices for shielded solid dielectric plastic cables shall be factory engineered kits containing all necessary components to reinstate primary cable insulation, metallic shielding, grounding system and overall jacket to the equivalent of the cable itself.
- C. Splices shall be of a uniform cross section heat-shrinking polymeric construction utilizing a high dielectric strength insulating layer. The insulating layer shall be bonded to a conducting layer for shielding. The splice shall be rejacketed with a heavy-wall, heat-shrinkable lined sleeve to provide a waterproof hot melt adhesive seal.
- D. The splice shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances.
- E. When assembled on cables, the splice shall be capable of passing the electrical test requirements of IEEE 48-1975, IEEE 404-1986, and water immersion tests of ANSI C119.2-1974.
- F. Splice manufacturer shall provide a test report demonstrating compliance with the above test requirements.
- G. Splices shall be manufactured by Raychem Corporation, or equal.

### 3.06 GUARANTEE

- A. Fully guarantee all work under this Section, for a period of TWENTY YEARS from the date of final acceptance by the Owner, against imperfect workmanship or failure or malfunction of materials due to faulty or imperfect workmanship. Give this guarantee in writing to the Owner at the time of issuing final certificate. Work found to be defective within this period shall be replaced without cost to the Owner.

### 3.07 ACCEPTANCE

- A. As a condition precedent to final acceptance of the work, the Contractor shall certify the material and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these manufacturer's guarantee.

End of Section

## SECTION 16325

## LIQUID FILLED - COMPARTMENTAL TYPE - PAD MOUNTED TRANSFORMERS

## PART 1 - GENERAL

## 1.01 DESCRIPTION

- A. This section covers liquid filled, compartmental type, pad mounted medium voltage transformer and its installation. The transformer shall be installed as shown on the Drawings.

## 1.02 REFERENCES

ANSI C57.12.00 - Liquid Filled Transformers  
 ANSI/IEEE C57.12.27 - Liquid Filled Transformers  
 ANSI/IEEE C57.12.90 - Liquid Filled Transformers  
 ASTM D877 - Liquid Filled Transformers Testing

## 1.03 SUBMITTALS

- A. Products shall be submitted to the Engineer in accordance with Section 16000 and other Contract Documents.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. The substation transformer shall be manufactured by Howard Industries, Square D, Westinghouse, ABB, or equal.

## 2.02 SUBSTATION TRANSFORMER

- A. Minimum transformer ratings shall be as follows:

|                           |               |
|---------------------------|---------------|
| <b>*kVA Rating</b>        | <b>1000</b>   |
| Impedance                 | 5.75%         |
| <b>*Primary Voltage</b>   | <b>12,470</b> |
| <b>*Secondary Voltage</b> | <b>2400</b>   |
| HV BIL                    | 95kV          |
| HV Taps                   | ± 2%          |
| LV BIL                    | 45kV          |
| <b>**Noise</b>            | <b>58db</b>   |



\* Refer to Single Line diagrams for more information.

\*\* Noise level is at 10 feet.

- B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 65 degrees C temperature rise, based on average ambient of 30 degrees C over 24 hours with a maximum ambient of 40 degrees C, as defined by ANSI C57.12.00, without loss of service life expectancy.
- C. All high voltage termination and equipment shall be dead front and conform to ANSI C57.12.26 requirements. Provide universal type bushing wells and parking stands for mounting accessory equipment. Bushings shall be externally clamped and front end removable. The terminations and equipment shall be arranged for radial feed.
- D. The transformer shall be the compartmental type, tamper and weatherproof. The transformer, high voltage compartment, and low voltage compartments shall be assembled as an integral unit. The high and low voltage compartments shall be pad lockable, located side-by-side, separated by a steel barrier. Coolant and insulating fluid shall be inhibited mineral oil. An externally operated tap changing mechanism shall be provided for accurate voltage adjustment without opening the transformer tank.
- E. The transformer shall be wound core type with copper windings. The transformer shall be designed to carry short time emergency overloads in accordance with ANSI C57.92 and NEMA TR 98 as applicable. Duration and magnitude of designed withstand capability shall be as outlined in ANSI C57.12 and the latest draft of the IEEE Short Circuit Test Code.
- F. Transformer features and accessories shall include de-energized tap changer with cover mounted, externally operated, padlockable handle; combination drain and filter valve and sampling device; one inch filling plug and filter press connection in cover; dial type top liquid thermometer; provisions for lifting; provisions for jacking; base designed for skidding or rolling in two directions; copper ground pad; instruction nameplate; welded-on main tank cover with handhole in cover.
- G. The main transformer tank and attached components shall be designed to withstand pressures 25% greater than the required operating design value without permanent deformation. Construction shall consist of carbon steel plate reinforced with external sidewall braces. All seams and joints shall be continuously welded.
- H. Each radiator assembly shall be individually welded and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final six hour leak test shall be performed after the transformer is tanked, welded and completed to ensure that there are no leaks before shipment from the factory.
- I. Each transformer shall be painted utilizing an initial phosphatizing cleaning treatment, followed by a baked-on epoxy primer. Transformers shall be outdoor type.

- J. Perform the following minimum tests. All tests shall be in accordance with the latest revision of ANSI Test Code C47.12.90 and/or NEMA TR1 and with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING:
1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.
  2. Ratio tests on the rated voltage connection and on all tap connections.
  3. Polarity and phase-relation tests on the rated voltage connections.
  4. No-load loss at rated voltage on the rated voltage connection.
  5. Exciting current at rated voltage on the rated voltage connection.
  6. Impedance and load loss at rated current on the rated voltage connection of each unit.
  7. Temperature Test or tests shall be made on one transformer unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one kVA rating, temperature tests as listed above shall be made on the lowest kVA OA or AA rating and the highest kVA FA rating.
  8. Applied potential test.
  9. Induced potential tests.

Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.

## 2.03 PROTECTIVE EQUIPMENT

- A. Provide drywell canister mounted current limiting fuses externally replaceable with distribution hot stick without opening the transformer tank. The fuses shall be current limiting, C rated silver sand type, and fully rated.

## 2.04 SURGE ARRESTERS

- A. Provide 10kV distribution class surge arresters mounted in the high voltage compartment for surge protection.

## 2.05 LOW VOLTAGE TERMINATION AND EQUIPMENT

- A. The low voltage bushings shall be molded epoxy and provided with blade type spade terminals with NEMA standard hole spacing. The low voltage neutral shall be an insulated bushing grounded to the transformer tank.

# PART 3 - EXECUTION

## 3.01 EXAMINATION

- A. Inspect to confirm that all items and accessories are in accordance with specifications and Drawings.
- B. Verify field measurements are as shown on shop drawings.

### 3.02 INSTALLATION

- A. Installation of equipment shall be such that sufficient access and working space is provided for ready and safe operation and maintenance.
- B. Install equipment on concrete pad, as indicated on the Drawings. Coordinate exact pad dimensions with equipment furnished.
- C. The transformer shall be mounted on a concrete pad. Units shall be carefully installed so as not to scratch finishes. After installation, finished surfaces shall be inspected and scratches touched up with a finish furnished by the manufacturer especially for this purpose.
- D. Concrete pads shall be constructed as indicated. Tops of concrete pads shall be level and shall project 4 inches above finished grade and sloped to drain. Conduits for primary, secondary, and grounding conductors shall be set in place prior to pouring of concrete pads.

### 3.03 FIELD INSPECTION AND TESTS

- A. Provide the services of an authorized representative of the equipment manufacturer to make site visits to supervise the field testing and installation to be performed by the Contractor. The manufacturer's representative shall state in writing that the equipment has been correctly installed and tested.
- B. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- C. Perform any other tests recommended by the equipment manufacturer and other tests as described in this specification.
- D. The manufacturer's representative shall supply results of all factory and field tests in writing for submittal to the Engineer.
- E. The manufacturer shall supply test results to confirm that the transformer assembly design has been tested to substantiate conformance with the applicable ANSI and NEMA Standards.
- F. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with Owner.

End of Section

## SECTION 16341

### MEDIUM VOLTAGE LOAD INTERRUPTER SWITCHGEAR

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

1. This section covers medium voltage load interrupter switchgear. This equipment shall be furnished by the manufacturer, and delivered to the job site for installation by the Contractor.

##### 1.02 REFERENCES

- A. ANSI/IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear (latest edition).
- B. ANSI/IEEE C37.20.4 - Standard for Indoor AC Medium-Voltage Switches used in Metal-Enclosed Switchgear (latest edition).
- C. ANSI/IEEE 24 - Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings (latest edition).
- D. ANSI/IEEE 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations (latest edition).
- E. National Electric Code.
- F. Other standards indicated herein.

##### 1.03 SUBMITTALS

- A. Products shall be submitted to the Engineer for review in accordance with the Contract Documents.
- B. Shop Drawings: Submit for review ten (10) copies of manufacturer's technical information for equipment proposed for use. Submittals shall include the following:
  1. Dimensional information of all components and unit substation assembly
  2. Single-line diagrams
  3. Wiring diagram for all control wiring
  4. Technical specifications
  5. Catalog cuts
  6. Time current curves for fuses and circuit breakers
  7. Master drawing index
  8. Front view elevation
  9. Floor plan
  10. Top view
  11. Nameplate schedule

12. Component list
13. Conduit entry/exit locations
14. Assembly ratings including:
  - a. Short-circuit rating
  - b. Voltage
  - c. Continuous current
  - d. Basic Impulse level
15. Major component ratings including:
  - a. Voltage
  - b. Continuous current
  - c. Interrupting ratings
16. Cable terminal sizes.
17. Busway connection
18. Connection details between close-coupled assemblies
19. Key interlock scheme drawing and sequence of operations.

C. Submit ten (10) copies of the following information for record purposes:

1. Final as-built drawings and information for items listed above
2. Wiring diagrams
3. Certified production test reports
4. Installation information including equipment anchorage provisions

1.04 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The metal enclosed load interrupter switchgear assemblies shall consist of deadfront, completely metal enclosed vertical sections containing load interrupter switches and fuses of the number, rating and type noted on the Drawings or specified herein. The metal enclosed switchgear assemblies shall meet the requirements of ANSI Standard C37.20.3, and NEMA Standards SG5 and SG6, and shall have the following minimum ratings:

Nominal System Voltage      4.16 kV three phase, four wire

|                        |              |
|------------------------|--------------|
| System Grounding       | solid        |
| Maximum Design Voltage | 5 kV         |
| Basic Impulse Level    | 60 kV        |
| Bus Continuous Current | 1200 Amperes |
| Momentary Current      | 50 kA        |
| Three Second Current   | 35 kA        |

- B. The load interrupter switches shall be quick-make, quick-break three pole, and gang operated. Each switch shall meet the requirements of ANSI Standard C37.20.4 and shall have the following minimum ratings:
- |                                          |             |
|------------------------------------------|-------------|
| Maximum Design                           | 5 kV        |
| Basic Impulse Level                      | 60 kV       |
| Continuous and Load Interrupting Current | 600 Amperes |
| Momentary Current                        |             |
| (Switch Closed, 10 cycle)                | 80 kA Asym. |
| Fault Close Current                      | 61 kA Asym. |
| Two Second Current                       | 38 kA       |
- C. The load interrupter switch shall have a manual over toggle type mechanism that does not require the use of a chain or a cable for operation, and utilizes a heavy duty coil spring to provide opening and closing action. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position.
- D. The interrupter switch shall have separate main and break contacts to provide maximum endurance for fault close and load interrupting duty. The interrupter switch shall have insulating barriers between each phase and between the outer phases and the enclosure. A maintenance provision shall be provided for slow closing the switch to check switch blade engagement and slow opening the switch to check operation of the arc interrupting contacts.
- E. The switchgear assemblies shall be integrally designed and produced by the manufacturer of the load interrupter switches to assure a completely coordinated design and establish one source of responsibility for the equipment's performance.

## 2.02 CONSTRUCTION

- A. The following features shall be supplied on every vertical section containing a three pole, two position open-closed switch:
1. A high impact viewing window that permits full view of the position of all three switch blades through the closed door.
  2. The door shall be interlocked with the switch so that:
    - a. The switch must be opened before the door can be opened.
    - b. The door must be closed before the switch can be closed.
  3. A grounded metal barrier in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
  4. Provision for padlocking the switch in the open or closed position.

5. Permanent "Open-Closed" switch position indicators.

- B. Fault protection shall be furnished by fuses as shown in the Contract Documents. The fuses shall have a minimum interrupting rating of 63k amperes symmetrical at 5.5 kV and shall be current limiting type. Furnish three spare fuses for each fused switch and provide a storage rack on the inside of the main door for these spare fuses.
- C. Vertical section construction shall be of the universal frame type using dieformed and bolted parts. All enclosing covers and doors shall be fabricated from not less than 11-gauge steel. Top cover shall be removable. Rear covers shall be bolted on.
- D. Each vertical section containing a switch shall have a single, full length, flanged front door and shall be equipped with two rotary latch type padlockable handles. Provision shall be made for operating the switch and storing the removable handle without opening the full length door. A nameplate shall be mounted on the front door of the switch vertical section.
- E. Prior to assembly, all enclosing steel shall be thoroughly cleaned and phosphatized. A powder coating shall be applied electrostatically, then fused on by baking in an oven. The coating is to have a thickness of not less than 2 mils. The finish color shall be ANSI-49 or ANSI-61 Gray.
- F. Each outdoor vertical section shall have a sloped weatherproof roof. All openings shall be screened to prevent the entrance of small animals, and barriered to inhibit the entrance of snow, sand, etc. A minimum of one 250 watt, 120 volt space heater shall be provided in each vertical section. Power for the space heater(s) shall be furnished by the transformer mounted within the switchgear assembly.

## 2.03 TESTS

- A. In accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

## 2.04 ADDITIONAL EQUIPMENT

- A. Mechanical Interlocks: The high-voltage compartment door shall be mechanically interlocked to prevent opening with the load interrupter switch in the closed position. The interlock must be directly attached to the operating handle and mechanism and should not rely on long cables or linkages.
- B. 5 kV station class surge arresters shall be provided, connected at the incoming terminations, one per phase, and securely grounded to the metal structure. The surge arresters shall be manufactured by Ohio Brass, or equal.
- C. The utility metering vertical sections shall contain current transformers and voltage transformers as required by the utility. It shall conform in all areas to the utility company metering standards including arrangement and size.
- D. Provide power for all devices used in switchgear using voltage transformers.



- E. Incoming Cable Terminations: Per Salt River Project specifications.
- F. double clamping lugs for terminating cables onto the switchgear terminal pads.
- G. Space Heaters: For 120 Vac internal source, sized by the manufacturer, with thermostats.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION (NOT IN THIS CONTRACT – TO BE INSTALLED BY CONTRACTOR)

- A. Installation of equipment shall be such that sufficient access and working space is provided for ready and safe operation and maintenance.
- B. Install equipment on concrete pad, as indicated on drawings. Coordinate exact pad dimensions with equipment furnished. Tops of concrete pads shall be level and shall project 4 inches above finished grade and sloped to drain. Conduits for primary, secondary, and grounding conductors shall be set in place prior to pouring of concrete pads.
- C. Switchgear shall be mounted on concrete pads. Units shall be carefully installed so as not to scratch finishes. After installation, finished surfaces shall be inspected and scratches touched up with a finish furnished by the manufacturer especially for this purpose.

#### 3.02 FIELD INSPECTION AND TESTS

- A. Provide the services of an authorized representative of the switchgear equipment manufacturer to make site visits to supervise the field testing and installation to be performed by the Contractor. The manufacturer's representative shall state in writing that the equipment has been correctly installed and tested.
- B. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- C. Perform any other tests recommended by the equipment manufacturer and other tests as described in this specification.
- D. The manufacturer's representative shall supply results of all factory and field tests in writing for submittal to the Owner.

#### 3.03 TRAINING

- A. The switchgear manufacturer shall be responsible for providing two (2) two-hour sessions of on-site training for up to ten (10) operation and maintenance personnel in each session. Training sessions shall be scheduled to accommodate night-shift personnel.



Provide training and reference manuals to each trainee. Training shall include as a minimum proper use of safety gear when servicing switchgear, review of recommended testing procedures, proper de-energizing procedures and Kirk key operation, and proper fuse replacement procedures. Training shall be scheduled prior to final acceptance of the equipment, and following energizing and testing of switchgear. All training shall be video taped and delivered to the Owner within one (1) week of the training sessions.

End of Section

## SECTION 16343

### MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

#### PART 1 - GENERAL

##### 1.01 SCOPE OF WORK

- A. This section covers medium voltage metal-clad switchgear assemblies.

##### 1.02 REFERENCES

- A. ANSI/IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear (latest edition).
- B. ANSI/IEEE C37.20.4 - Standard for Indoor AC Medium-Voltage Switches used in Metal-Enclosed Switchgear (latest edition).
- C. ANSI/IEEE 24 - Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings (latest edition).
- D. ANSI/IEEE 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations (latest edition).
- E. National Electric Code.
- F. Other standards indicated herein.

##### 1.03 SUBMITTALS

- A. Products shall be submitted to the Engineer for review in accordance with Section 16000 and other Contract Documents.
- B. Shop Drawings: Submit for approval copies of manufacturer's technical information for equipment proposed for use. Submittals shall include the following:
  - 1. Dimensional information of all components and unit substation assembly
  - 2. Single-line diagrams
  - 3. Wiring diagram for all control wiring
  - 4. Technical specifications
  - 5. Catalog cuts
  - 6. Time current curves for fuses and circuit breakers
  - 7. Construction details of unit substation walk-in enclosure complete with lighting, receptacles and heaters (if applicable).
- C. Certification of Ratings: Submit for approval copies of certified test reports as indicated elsewhere in these specifications.

- D. Certified test reports establishing such ratings shall be furnished.
- E. Submit record drawings, accurately recording actual equipment's location, cable routing, and connections.
- F. Certificates to substantiate equipment compliance with standards and requirements indicated in the Contract Documents.

## PART 2 - PRODUCTS

### 2.01 GENERAL

- A. The scope is to furnish and install metal-clad switchgear as described in this specification and as detailed on the applicable drawings.
- B. The Contractor shall be responsible for the erection, installation and start-up of the equipment covered by this specification.
- C. The metal-clad switchgear and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA SG-4 and SG-5, IEEE, and but not limited to , ANSI 37.20.2.
- D. The circuit breaker shall be of the same manufacturer as the metal-clad switchgear. The switchgear shall be manufactured by Westinghouse, Square D, Siemens, or equal.

### 2.02 CONSTRUCTION

- A. The switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit. Two rear covers shall be furnished for each vertical section for circuit isolation and ease of handling.
- B. Buses and Connections: The main bus shall be copper and have fluidized bed epoxy flame retardant and track-resistant insulation. The bus supports between units shall be flame-retardant, track-resistant, [glass polyester for 15kV class] [cycloaliphatic epoxy supports for 27kV class]. All bus joints shall be plated, bolted and insulated with easily installed boots. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers. The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests. A copper ground bus shall extend the entire length of the switchgear.
- C. Circuit Breaker Compartment: The circuit breaker compartment shall be equipped to house the removable breaker element. The mechanism for levering the breaker shall be cell mounted and include all of the necessary interlocks to render the breaker mechanism